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SAMPLE SURVEYS FOR IMPROVEMENT OF LIVESTOCK STATISTICS

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH NEW DELHI

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LIVESTOCK STATISTICS

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SAMPLE SURVEYS FOR IMPROVEMENT OF LIVESTOCK STATISTICS

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The need for collection of the statistics of livestock in India was recognised by the Govt. of India in 1919. Since then eight censuses have been recorded. The Animal husbandry Committee of the ICAR took up the work of compiling exact statistics of the livestock position iu 1949

With a view to determine the feasibility and usefulness of sampling methods in rationalising the methods of supervision and improving the quality of the census data and to evolve a techniquc of sample enumeration useful in furnishing independent and timely estimates of reasonable accuracy of livestock numbers under mojor categories for broad administrative units of the Indian Union. It was further desired to implement in conjunction with the forthcoming census (i) rationalisation of supervision and (ii) sample enumeration, immediately after the census of 1956 was over. It is hoped that this sample survey will provide material useful in improving the plan for similar country-wide surveys that may be repeated, if necessary in the following inter-census year.

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PREFACE

This publication contains an account of the work done by the Indian Council of Agricultural Research under the scheme for the improvement of livestock statistics initiated by the Council. The project terminated when this work was transferred to the National Sample Survey in 1955.

The pilot sample surveys were conducted in the districts of Etawah and Wardha in Uttar Pradesh and former Madhya Pradesh, respectively, during 1950-51 and 1953. Based on the results of these surveys, a state-wide sample survey was conducted in the former Bombay State in 1954 for the purpose of formulating techniques which may be suitable for country wide adoption.

The present publication gives the description of these surveys and the results of the investigation leading to the recommendation of sampling procedures to be adopted for estimating livestock numbers under Indian conditions.

The project was a co-operative effort between agricultural and animal husbandry departments of the States concerned and the Statistical Wing of the Indian Council of Agricultural Research. Its success was primarily due to the active interest taken in the investigations by Directors and other officers of the concerned departments in the states. Special mention must be made of Shri D.S. Ranga Rao, Statistician, Department of Agriculture, Bombay State, whose whole hearted co-operation was largely responsible for the successful conduct of the survey in Bombay State. Among the statistical staff of the Council special reference should be made of Shri Daroga Singh who was mainly responsible for consolidating the results and drafting this report. Shri A. S. R. Sharma, M. Rajagopalan and V.S. Rustogi also did very useful work in carrying out the statistical analysis of the data ; and, otherwise, contributed to the preparation of the report.

V. G. PANSE
Statistical Adviser

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CHAPTER I
LIVESTOCK AND THEIR PRODUCTS

Indian economy depends primarily upon agriculture, which is the direct avocation of 70 per cent of India's population. Livestock plays an important part in agriculture and the prosperity of the country is concomitant with that of livestock. According to the Final Report of the National Income Committee (1954), livestock products contributed 663 crores of rupees to the national income of India in 1950-51. This amount constituted 16 per cent of the income from agriculture or 7 per cent of the total income and was the fourth major item in the list of national income. This position of livestock in the national economy points to the importance of obtaining reliable estimates of livestock numbers in different categories and their products. With plans for large scale improvement of livestock under contemplation and in operation this need is more urgent now than before.

QUINQUENNIAL LIVESTOCK CENSUSES

Since 1919, collection of livestock statistics has been done through quinquennial censuses. Uptill now eight such censuses have been conducted, the latest being in April, 1956. Up to 1945 the census of livestock related to the British India and a few of the Indian States. In 1951 its coverage was extended with the political reorganisation of states after independence and it was complete in 1956 except for the States of West Bengal, Orissa and Manipur where the census was taken later (March-April, 1957 in Orissa and Manipur and in December, 1957 in West Bengal).

The responsibility for collecting livestock data rests upon State Governments. Data are collected for each village and are then tabulated according to successive administrative units such as talukas, districts, divisions and States. The Ministry of Food and Agriculture of the Central Government co-ordinates these data at an all-India level.

The field collection of data is entrusted to the normal land revenue agencies, other allied departments and *ad hoc* enumerators drawn by State Governments from their Animal Husbandry and Revenue Departments. In places where there is no land revenue agency, village *chowkidars*, school teachers or staff of the village *panchayats* are asked to collect data. In urban areas the services of the sanitary staff are drafted for work in the municipalities. Although human census and livestock census have not been co-ordinated so far, it is now proposed that the alternate livestock censuses should coincide with the decinnial

human census in order to facilitate the availability and completeness of household frame.

Since 1945, many improvements have been introduced in the livestock census. Not only has the geographical coverage increased, but more items have been included for enumeration. Data are now more uniform as a result of better co-ordination and consequently are more comparable from State to State. The procedure followed in 1956 census was that the enumerators were instructed to complete within a fortnight or a month before the reference date, the preliminaries such as listing of households, contacting their owners for requisite information, etc., in respect of villages under their jurisdiction. The definitions of household and village were same as in the human census of 1951. The enumerator had to record data in the prescribed proforma by oral enquiry supplemented, wherever possible, by a spot check. If the owner was absent the information was collected from other members of the household or the neighbours. The enumerators were required to go round the villages on the reference date, April 15, 1956 and note the changes, if any, and bring the data up-to-date as relating to the position at sunrise on the reference date.

All living animals belonging to individual households, Gosadans and other societies and unowned animals were to be enumerated. Cattle and buffaloes were classified as under :

1. Males and females above 3 years.
2. Young stock between 1 year and 3 years and under one year.

Ovines, namely, sheep, goats, and horses and ponies were also recorded according to age and sex. In addition, poultry were recorded under the heads, cocks, hens, chickens etc., and also agricultural implements comprising of improved and *desi* ploughs (wooden and iron), oil *ghanis*, sugarcane crushers, etc.

The instructions for enumeration were drawn by the States themselves on the basis of those supplied from the Centre. Supervision was carried out by the officers of the departments which had been entrusted with the enumeration work. State Governments were required to bring out a State Livestock Census Report, containing tehsil-wise information on livestock numbers, agricultural implements , poultry, etc. The Directorate of Economics and Statistics published the consolidated results at the all-India level in the Indian Livestock Census Vol. I and II. Volume I contains all-India and state-wise summary Tables, along-with an explanatory memorandum reviewing the changes in livestock numbers since the last census and commenting on general livestock condition in the States, briefly touching the subjects of breeds, diseases, veterinary services, etc. Volume II contains detailed all-India and district-wise Tables.

NEED OF SAMPLE SURVEYS

Although complete enumeration is sound in principle, yet in practice it is attended with errors the magnitudes of which are not known. The primary reporters are given charge of 4 to 5 villages on the average. The heavy work entrusted to them is liable to tell upon their efficiency. It is alleged that proper attention or care is not given to this work by the enumerators and their supervisors, and the enumeration is full of inaccuracies.

Statistics collected from censuses conducted quinquennially cannot meet all the needs of livestock development. Statistics collected annually have an important role to play. Study of short-term trends in livestock population would be necessary for orientation of development plans envisaging better utilization of livestock and a greater output of their products. Determination of an overall plan for balancing numbers of livestock to the limited food resources requires statistics on annual basis. In fact, the practice of annual enumeration of livestock numbers is in vogue in some states. This annual census is conducted again, through village patwari, along with crop inspection and the work is usually spread over a period of 3 to 4 months. The estimates obtained suffer from the defects of double counting and exclusion of ownerless and houseless cattle. The chances of other errors are greater when this enumeration is held annually. To eliminate these difficulties from the way of the annual enumeration, the estimates will have to be obtained through sample surveys. Sampling methods are like a flexible tool with which quick and reliable statistics can be obtained.

Formulation of Scheme. In India, in 1949, the Animal Breeding Committee of the Indian Council of Agricultural Research taking note of the unsatisfactory position of livestock statistics, requested the Statistical Adviser, I.C.A.R., to formulate a scheme with the twin objective of :

1. Evolving sampling technique for estimating numbers of major categories of livestock, such as, cattle, buffaloes, poultry and sheep during inter-census years ;

2. Providing a scientific and rationalised method of supervision on the work of primary enumeration during census years in order to ensure reliability of the results.

With these objectives the first pilot sample survey was conducted in 1951 in the district of Etawah in U.P. This was followed by another survey under different conditions in the district of Wardha in the former State of Madhya Pradesh in 1953. The results of these surveys were utilised for extending of the survey on a state-wide scale in the former Bombay State during 1954. The description of these surveys is detailed in Chapter 2.

CHAPTER II

DESCRIPTION OF SAMPLE SURVEYS

SURVEY IN ETAWAH DISTRICT

Two pilot surveys were proposed to be conducted during 1950-51 in two districts, one each in Uttar Pradesh and Madhya Pradesh. However, on account of a sudden outbreak of rinderpest epidemic in Madhya Pradesh, the survey was confined to Uttar Pradesh only. Etawah district was selected for this purpose, possessing as it does representative bovine population in large numbers. The object of the survey was to examine the feasibility of using sampling methods for estimating livestock numbers of major categories with reasonable precision for broad administrative units like districts.

TABLE* I. LAND UTILISATION AND AREA SOWN UNDER DIFFERENT CROPS IN 1950-51

Land utilisation		Area under crops	
Description	Area (thousand acres)	Crop	Area (thousand acres)
Net area sown	653	*Bajra*	191
Not available for cultivation	266	Barley	97
		Wheat	97
		Maize	77
Other uncultivated land excluding current fallows	89	*Jowar*	41
		Rice	35
Fallow land	33	Sugar	28
		Fodder	26
		Other crops	172
Forest	42		
Total geographical area according to village papers	1083	Total area sown	764

*From Indian Agricultural Statistics 1950-51 and 1951-52 Vol. II (Detailed Tables).

The district of Etawah lies in the south-western portion of Uttar Pradesh. It has a total area of 1083 thousand acres of which the rural area is 1072 thousand acres. There are four tehsils, namely, Etawah, Bharthana, Auraiya and Bidhuana, each possessing more or less equal rural area. The population of the district was, according to the human census of 1951, 9.7 lakhs of which 90 per cent constituted the rural population. It was distributed evenly among different tehsils. The population density was 575 per square mile for the district as against 557 for the State as a whole. Since 1921, the population has been showing an upward trend and during the period 1941-51 it registered an increase of 9 per cent. There were 7.0 persons per house and 5.2 persons per household in rural areas.

The annual rainfall is over 29 inches. Vegetation is scanty and runoff and soil erosions are high. The soils can broadly be classified as loam, clay and sand. The most prevalent soil type is loam, locally known as 'dumat'.

The total net irrigated area constituted 38 per cent of the net area of 653 thousand acres sown, during 1950-51. The source of irrigation was mainly canals and wells.

Table I shows area of the district according to land utilisation and area under different important crops in 1950-51.

SAMPLING PLAN

There are in all 1519 villages in the district. The plan adopted for the livestock survey was one for single-stage sampling design. Tehsil and village constituted a stratum and a unit of sampling, respectively. The survey was confined to the rural parts of the district. The total number of villages selected with equal probability as a sample was 210. The following statement shows the distribution of the sample among the tehsils :

Name of the Tehsil	Total No. of villages	No. of villages selected	Percentage sampling fraction
Bharthana	309	42	13.6
Etawah	362	56	15.5
Auraiya	417	56	13.4
Bidhuana	431	56	13.0
District	1519	210	13.8

Out of the 210 villages selected for the survey, enumeration was carried out in all but one which was found to be an urban area and was excluded.

Field-Work. The field work was conducted by an *ad hoc* staff of 15 enumerators drawn out of the stockmen of the Animal Husbandry Department of the State. There were two supervisors to inspect field work and their supervision was supplemented by the officer-in-charge of the survey selected from the Animal Husbandry Department. The administrative control of the survey rested with the Director of Animal Husbandry, Uttar Pradesh.

Each enumerator was allotted 14 villages within a contiguous area. A suitable itinerary was prepared for him in regard to movement from one village to another. On the average, an enumerator was to cover two villages in a week. Also, a programme of supervision was drawn up which required that the supervisors should be present with each of the enumerators, at least in one village, under their jurisdiction for providing necessary guidance. Besides, each supervisor was asked to enumerate a portion of households in two more villages allotted to each enumerator, one before and the other after enumeration by the enumerator. The supervisors were directed to submit their returns independent of the enumerators to the Statistical Adviser of the Council. This procedure enabled the study of discrepancies between entries of the two for the common sub-sample.

The field staff was trained by a statistical officer from the Council. Training included practical demonstration in the village.

Actual enumeration commenced on the 9th February, 1951 in the two tehsils, Etawah and Barthana and on the 16th February, 1951 in the remaining two. It was completed by the end of March in the former and on the 8th April in the latter two tehsils.

It should be noted that a frame for households was not readily available and consequently, preparation of a complete list of households was found necessary. Forms and instructions for recording data were prepared in consultation with the Director of Animal Husbandry, U.P.

SURVEY IN WARDHA DISTRICT

Wardha District is situated in the South-Western portion of the former State of Madhya Pradesh and is now a part of Bombay State. According to 1951 census, total area of the district was, 1558 thousand acres of which 1552 thousand acres constitute rural area and the remaining urban area. The district consists of three tehsils, namely, Arvi, Wardha and Hinganghat, in which the rural areas are 567, 520 and 465 thousand acres, respectively.

The population of the district in 1951 was 5.4 lakhs of which rural and agricultural population accounted for 77 per cent and 66 per cent, respectively. The density of population was 221 per sq. mile for the district.

The soil of the district is mainly black cotton soil. The normal rainfall is 41 inches annually.

Table II shows the areas* in acres for the district during 1952 53 under different items of classification of land utilisation and the areas under important crops.

TABLE II. LAND UTILISATION AND AREA SOWN UNDER DIFFERENT CROPS IN 1952-53

Land Utilisation		Area under Crops	
Description	Area (thousand acres)	Crop	Area (thousand acres)
Net area sown	980	*Jowar*	335
Not available for cultivation	165	Pulses	124
		Wheat	82
Other cultivated area excluding current fallows	240	Rice	4
Fallow lands	28	Fodder	9
Forests	141	Other crops	430
Total geographical area according to village papers	1554	Total area sown	984

The net irrigated area in the district during 1952-53 was only 9108 acres accounting for nearly 1 per cent of the total area sown. Wells were the source of irrigation for 9013 acres.

Object of the Survey in Wardha District. The pilot survey in the district of Etawah was followed during 1953 by another survey in the district of Wardha. The objectives of the survey were the same as those of the earlier survey. As before, it was confined to the rural parts of the district.

SAMPLING PLAN

The plan of the survey was also one of stratified single-stage sampling design. It may be recalled that one-way stratification by taking tehsils as strata was adopted in the survey in Etawah district. It was considered desirable to study the advantages, if any, of a two-way stratification not only by tehsils, but also by size of villages within tehsils, size being determined by number of the households; information on which was available from the human census of 1951. Accordingly, Wardha district was divided into geographical strata which corresponded

*Based on Indian Agricultural Statistics Vol. II 1952-53.

to tehsils. Within each one of them size strata were formed corresponding to the groups of villages containing:

1. 50 households or less,
2. from 51 to 125 households,
3. 125 households or above.

There were thus 9 sub-strata. The unit of sampling was a village. Approximately the same number of villages was randomly selected with equal probability from each stratum. In all, 125 villages were chosen out of 928 in the district. The number of villages selected in each sub-stratum, along with the percentage sampling fraction, is given below:

Tehsil \ Size	I	II	III	Total
Arvi	13 (10.2)	14 (12.8)	14 (17.3)	41
Wardha	14 (16.3)	14 (11.6)	14 (12.2)	42
Hinganghat	14 (11.4)	14 (13.6)	14 (22.2)	42
District	41 (12.2)	42 (12.6)	42 (16.2)	125

Information Collected. Data were collected on cattle, buffaloes, sheep, goats, horses and ponies according to age and sex. Poultry comprising of hens, cocks and chickens and agricultural machinery such as ploughs, blade harrows, carts, etc., were also enumerated. Among cattle and buffaloes, provision was made for recording the data under the sub-classifications of breeding bulls, working bulls and bullocks, and others for males; and in milk, dry and not calved for females. In addition, information on agricultural statistics was collected for selected villages.

Organisation of Field Work. The field work was conducted by twelve enumerators selected from amongst the stock supervisors of the State Veterinary Department. Two supervisors were provided for supervision of the field work. The administrative control of the work was entrusted to the Director of Veterinary Services, Madhya Pradesh, who exercised it through the Deputy Director, Nagpur Division.

Each enumerator was allotted a group of 9 to 14 villages, the actual number being so chosen, as to approximately equalise the total number of households for each enumerator. A time schedule was drawn up for each enumerator, so as to enable him to cover the villages in order of geographical proximity. The enumerators were instructed to prepare two copies of the list of households in the prescribed form from

tehsil office for each of the villages allotted to them, and send one copy to the supervisor concerned.

Supervision was carried out on a sub-sample of 50 villages and 20 households in each, selected in the form of clusters of five contiguous households each. The supervisor was asked to enumerate about one-third of sample villages in advance of the enumerator and the remaining after him. Both the enumerators and supervisor were directed to send returns direct to the Statistical Adviser of the Council. This enabled a study of discrepancies between their entries for the common sub-sample. The actual enumeration work was carried out from 15th January, 1953 to 28th February, 1953.

Field work was completed in all the sampled villages and returns were received for all except one, which was lost in transit.

SURVEY IN BOMBAY STATE

The surveys carried out in Etawah and Wardha districts served the purpose of determining broad features of the sampling plan that would be suitable for enumeration of livestock. Before recommending it for large-scale application it was considered desirable to try the sampling technique evolved on a substantial area. Bombay State was chosen for this purpose and the survey was carried out during 1954. Extending over an area of nearly 71 million acres Bombay State, prior to reorganisation of States, consisted of 28 districts and 303 talukas. The total number of villages and towns was 34, 227 and 499, respectively.

The human population, according to 1951 census, was about 36 million. The rural population accounted for 69 per cent of the total. The density of population was 323 per square mile.

From the soil and climatic points of view the State may be broadly divided into four divisions as given below:

Division	Number of districts	Names of districts
Gujerat	10	Ahmedabad, Kaira, Broach, Panchmahals, Surat, Sabarkantha, Banaskantha, Amreli, Mehsana and Baroda
Konkan	4	Kanara, Kolaba, Thana and Ratnagiri
Deccan	8	East Khandesh, West Khandesh, Nasik, North Satara, Sholapur, Ahmednagar, Poona and Dangs
Karnatak	5	Belgaum, South Satara, Kolhapur, Bijapur and Dharwar

The Konkan area receives the highest annual rainfall, the normal

being 108 inches and it decreases as one goes to the east and the north in the Gujerat area. In the Deccan tract it is a little over 30 inches, 36 inches in the Gujerat area, and 35 inches in Karnatak area. The soils in the State are varied. While alluvial soils are found in the north Gujerat area, laterites are found in Ratnagiri and Kanara districts. The Deccan tract is of black cotton soil. In the Karnatak division a wide range of soils is encountered such as red soils in Belgaum, black soils in Bijapur and loamy brown soi's in Dharwar. In the other two districts all these three types are found.

During 1953-54, land utilization and areas under important crops for the State were as given in the following statement*.

Land utilisation		Area under crops	
Description	Area (thousand acres)	Crop	Area (thousand acres)
Net area sown	42,926	Jowar	11,426
		Bajra	7,706
Not available for cultivation	7,291	Rice	3,286
Other uncultivated area excluding current fallows	5,897	Wheat	1,973
		Pulses	4,351
Fallow land	4,016	Oil-seeds	3,752
		Other crops	12,384
Forest	10,841		
Total geographical area according to village papers	70,971	Total area sown	44,878

The net irrigated area was 2385 thousand acres, accounting for 5 per cent of the total area sown. The source of irrigation was mainly wells.

Plan of the Survey. Unlike the earlier two surveys, the present survey was carried out both in rural and urban areas. The plan of sampling for the rural part was one of multi-stage design. Districts were treated as strata. The successive stages of sampling units were, taluka, village and cluster of occupied houses. At the primary or taluka stage selection was done with replacement with probability proportional to bovine population as obtained during 1951 livestock census. The number of talukas selected in each district was in

*Indian Agricultural Statistics 1953-54, Vol. I (Summary Tables)

proportion to its bovine population. Simple random sampling was followed for selecting the units at the other stages.

Out of 303 talukas, 88 distinct talukas were chosen and since the selection was with replacement, some talukas were repeated, thus bringing the total number to 110. The number of villages selected in a taluka constituted a multiple of eight, the multiple being determined by the number of times the taluka was repeated. Four clusters of 5 consecutive occupied houses were chosen in each village in the sample.

For estimating bovine population in urban areas, one or two towns per taluka were selected with replacement with probability proportional to number of houses in 1951 census and four clusters of five consecutive occupied houses in the selected towns were chosen by the method of simple random sampling for livestock enumeration.

A Special Study in Poona District. The study of efficiency of size stratification was continued but was confined to the district of Poona. Sixty villages were chosen in this district after grouping all villages into three size-strata as following :

1. Villages having less than 75 occupied houses
2. Villages having more than 75 but less than or equal to 200
3. Villages having more than 200 houses

The number of villages selected from the three size strata were roughly in proportion to the number of occupied houses in them. The actual number of villages selected in the three strata were 10, 19 and 31 respectively.

Organisation of Field Work. The field work was carried out for six weeks from the middle of May to the end of June, 1954 by an *ad hoc* staff of 55 enumerators and 11 Agricultural Assistants taken from the Department of Agriculture of the State. Each enumerator was given the work of enumeration in about 16 villages and one or two towns distributed in one or two talukas. He was required to complete the work in each village within two days. The programme of movement from one village to the other was drawn up for each enumerator.

Supervision was done by five *adhoc* inspectors each having the jurisdiction roughly corresponding to that of a Deputy Director in the State Department of Agriculture.

Information Collected. Apart from the general Agricultural statistics collected for selected villages, the items recorded were bovines, ovines, poultry and agricultural implements. The data for bovines and ovines were recorded according to age and sex. The age classification for bovines was :

1. Above three years,
2. Between 1 and 3 years,
3. Below 1 year.

Among ovines, horses and ponies were recorded as under and above 3 years, and goats and sheep as under and above one year. In poultry, hens, cocks and chickens were enumerated and among agricultural implements ploughs, harrows, oil *ghanis*, sugarcane crushers, etc., were recorded.

The forms employed for recording data in the survey are given in Appendix IV.

Returns were received for 862 villages out of 880 villages selected for the survey and 89 towns out of 91 in the sample. The analysis of the data was based on 837 villages distributed over 109 talukas. Returns for 25 villages were rejected for lack of completeness.

CHAPTER III

RESULTS OF SURVEYS

ETAWAH SURVEY

Etimates of Cattle, Buffaloes and Bovines. Table III presents estimates of total numbers along with sampling errors for cattle, buffaloes and bovines for each tehsil and for the district as a whole. The district estimate for bovines was 5.2 lakhs of which cattle constituted 46 per cent and buffaloes 54 per cent. The corresponding figures for the livestock census of 1950-51 conducted a month after the survey had been completed, which were 49 per cent cattle and 51 per cent buffaloes out of a total population of bovines of 5.4 lakhs.

The sampling errors of the estimates of cattle, buffaloes and bovines for the sample survey were 6.7 per cent, 5.6 per cent and 5.8 per cent respectively. The corresponding ratio estimates built up by using the number of households, as ancillary information had the sampling errors of 4.1 per cent, 2.4 per cent and 2.6 per cent respectively. The percentage reduction in errors was thus substantial, being 29 per cent, 64 per cent and 54 per cent respectively. The ratio estimates of livestock for the district could not be computed since the population values of the number of households in the district as they existed at the time of survey, were not known. The estimates for tehsils were accompanied by larger sampling errors, *i.e.*, 7 to 16 per cent, indicating that it would not be possible to estimate livestock numbers for individual tehsils with reasonable precision with the intensity of sampling adopted.

Table IV shows estimated totals for both cattle and buffaloes under following four heads :

1. Males over 3 years,
2. Females over 3 years,
3. Young stock between 1 and 3 years,
4. Calves under one year.

Adult animals accounted for 71 per cent and 67 per cent of the total for cattle and buffaloes respectively, as against the corresponding 1950-51 census figures of 67 per cent and 71 per cent. Except from tehsil Bidhuana, where the sex ratio was found to be the same both for adult cattle and buffaloes, there was predominance of males among cattle and of females among buffaloes. This clearly pointed to the preference of owners to male cattle for work and she-buffaloes for milk.

Table IV presents also percentage sampling errors of tehsil and district estimates of the four classes of cattle and buffaloes. It can

be seen from this Table that the district sampling errors were only of a slightly higher order than those obtained for the totals. They varied from 6.4 to 8.7 per cent for cattle and 5.5 to 7.7 per cent for buffaloes. Therefore one can conclude that estimation of livestock numbers under these heads also, is feasible along with totals for a district with the scale of sampling adopted.

Comparison with Census Estimates. In Table VI are given survey and census estimates for different classes of animals among cattle and buffaloes. Sampling errors for survey estimates are also presented for easy reference. It can be seen from Table VI that there is no statistical significant divergence between the figures except in the categories of young stock between 1 and 3 years, and calves under one year among cattle; and in the category of calves under one year among buffaloes. This divergence may partly be attributed to the time lag of one and a half months between the survey and census, and partly due to trade movement of working cattle in the month of March which precedes the harvesting and thrashing seasons. The accuracy of the census figures is frequently questioned and opinion has been expressed that the *patwari* who is entrusted with enumeration work, does not pay sufficient attention to this work. Present results show that the livestock census gives reliable information at least for broad categories of livestock at the district level.

Data Collected by Supervisory Staff. It has already been pointed out in Chapter 2 that provision was made for an independent enumeration during the survey by inspectors, to facilitate comparison of the estimates by the two agencies and provide a check on the work of enumertors. Data by both agencies for 639 households spread over 15 villages were available. Table V gives the estimates obtained from the data. Calculation of sampling errors was not attempted because of the small sub-sample. Enumerators' estimates of totals were lower by 5 per cent, 1 per cent and 10 per cent for bovines, buffaloes and cattle respectively than the Inspectors' estimates. The large difference in cattle was mainly accounted for by a large difference in young stock between 1 to 3 years and calves under one year. There was fair agreement in all the subheads except these two. This large difference in young stock may be largely due to the enumerators not taking proper count of untied calves at the time of their visits and also in part due to the movements of newly calved cattle.

Miscellaneous Items. Table VII presents the estimates of sheep, goats, and horses and ponies, and agricultural implements along with corresponding census figures. The first three categories were estimated at 12, 118 and 9 thousand, respectively. The estimates for sheep and horses and ponies were associated with large sampling errors of

20.7 per cent and 10.3 per cent, respectively. It can be seen that only in respect of horses and ponies the estimated and census figures were significantly different. It seems, therefore, that during the census this category of animals was not enumerated properly.

In regard to agricultural implements, *desi* ploughs, improved ploughs and carts were estimated at 104, 13 and 23 thousand respectively with percentage sampling errors of 5.6, 9.5 and 7.8 percent respectively. Again, there is no divergence between the census and the survey estimates.

Ratios of estimated number of ploughs and carts to the estimated number of draught cattle, calculated roughly by adding one-fourth of the number of young stock between 1 and 3 years to the number of male cattle above 3 years were one plough per every two draught animals and one cart for every nine draught animals. It was estimated that there were about 18 ploughs per 100 acres of net area sown.

Sample Size. Table X presents the analysis of variance for cattle, buffaloes and bovines, and estimates of true variances between villages in each tehsil. If village variances are compared with those of households for the district, it can be seen that the ratio of the latter to the former was about 8 for cattle, about 13 for buffaloes and about 10 for bovines, and it emphasizes the necessity of controlling this component of variation in any future survey by selecting a suitable number of households per village. Although the plan of the survey was a single stage sampling design, the data collected enabled the study of scale of sampling required in a sub-sampling design with villages and household as successive stages of sampling units. Table XI presents the results obtained for bovines, cattle and buffaloes separately. If the pattern of distribution of different categories of animals in different districts of the state is similar to the one under survey, about 1882 villages would be required with enumeration of 20 households in each village in order to obtain the total for bovines with 2 per cent sampling error. The corresponding figures for cattle and buffaloes are 2930 and 1738. These numbers presuppose the distribution of villages among strata in proportion to the total number of households in each stratum. In Table XI the figures in brackets indicate the corresponding numbers of villages to be selected when the ratio method of estimation is employed, using the number of households in a village as the auxiliary variate. It can be seen that there is a considerable reduction in the number of villages to be selected. For example, for estimating the cattle population with 2 per cent sampling error and enumerating 20 households in a village the number decreased from 2930 to 1089. These results show that in future, while planning such surveys the information on the number of households in a village

should be used with advantage to increase the precision of the estimate either by selecting the villages with probability proportional to the number of households in the village or by using this number as an auxiliary variate in building up the estimate of cattle or bovine population by ratio method of estimation. The information on the number of households can be readily obtained from the human population census.

It should be noted that beyond 20 households the decrease in number of village was considerably slow, 20 households might be, therefore, the appropriate number for selection at the secondary stage. This important finding influenced the surveys which followed.

WARDHA SURVEY

Estimates of Cattle, Buffaloes and Bovines. Table IX presents for each tehsil and for the district as a whole, estimates for number of buffaloes, cattle and bovines, with their sampling errors. The bovine number was estimated as 4.1 lakh for the district of which cattle constituted 88 per cent and buffaloes only 12 per cent. The corresponding census figures of 1951 were 90 per cent and 10 per cent respectively.

The estimate of bovines for the district was accompanied by 4.6 per cent sampling error while the values for tehsil estimates varied from 5.6 to 9.2. The percentage sampling errors for district estimates of cattle and buffaloes were 4.5 and 9.2 respectively and tehsil-wise sampling errors varied from 5.8 to 9.2 for cattle and from 7.1 to 16.8 for buffaloes. With cattle constituting the predominant bovine population in the district, their estimate for the district has an adequate degree of precision and even tehsil estimates are reasonable. Buffaloes are estimated with much larger errors both for the district and individual tehsils. It should be noted that sampling errors for cattle as well as buffaloes are distinctly lower in Hinganghat tehsil than the other two tehsils.

For cattle with their predominant number, a ratio estimate with a number of households as ancillary information was built up. The ratio estimate was obtained as 3.59 lakhs, and was associated with 3 per cent sampling error giving a reduction of nearly 33 per cent in the error. This is in conformity with the finding of the earlier survey in Etawah district.

It may be recalled that enumeration of four clusters of five households each in 50 villages selected out of the total sample of 126 was done independently by inspectors. The data so collected made independent estimates possible. This estimate was tried for cattle only.

It should be noted that the sampling fraction for each stratum varied from 2.4 to 12.7 per cent, the overall sampling fraction for the district being 5.2. Table XVI presents the estimates, along with sampling errors, for each stratum. The estimate of cattle population was nearly

3.2 lakhs as against 3.1 lakhs obtained from the enumerators' data. The inspectors' estimate was attended with 9 per cent sampling error while the latter, as already given in Table IX, had a sampling error of 4.5 per cent. The estimates were of the same order, revealing no statistical difference between them.

Comparison with Census Estimates. It would be interesting to compare the estimates obtained with those available in the census of 1950-51 and annual estimates of 1951-52. Table XIV gives the estimates, with sampling errors of the survey for easy reference. The estimates for cattle and bovines showed an increase of 2.4 per cent and 4.3 per cent over the annual enumeration of 1951-52, which themselves were 6 per cent and 4.3 per cent more than those for the year 1950-51. It should be noted in this connection that the figures did not relate to the same period of time. While the survey estimates referred to January-February, 1953 the census figures of 1950-51 related to May, 1951 and those of 1951-52, to March-April 1952. In respect of cattle and bovines the survey estimates were not significantly different from the census figures. But the survey estimates for buffaloes were appreciably larger indicating a real difference although the sampling error of the survey estimate was 9 per cent. A possible explanation is that there was an increase in the number of buffaloes in the district after the 1951-52 census.

Miscellaneous Items. Estimates for different age classes for cattle are given in Table XV. Of the estimate of 3.6 lakhs, those above 0 years accounted for 68 per cent; those between 1 and 3 years, 21 per cent and the remaining were under one year. The corresponding figures from the census of 1950-51 were, 68.1, 19.4 and 12.5 respectively. The sampling errors of estimates in these classes were slightly more than those for the total (Table XV). Thus, it is confirmed that livestock numbers in each age class can be estimated, more or less with the same order of precision, as for the totals with the intensity of sampling adopted. As the buffaloes constituted a minor percentage (nearly 12 per cent) of the total bovine population in this district, no attempt was made to sub-classify the buffalo population under different age groups.

The totals for poultry, goats and sheep were estimated at 113 thousand, 71 thousand and 9 thousand respectively, as against the census figures (1950-51) of 77 thousand, 52 thousand and 6 thousand. Female goats and sheep in the district constituted 57 per cent and 64 per cent of their respective totals, those under one year accounted for 45 per cent and 29 per cent. The distribution of poultry, goats and sheep among the tehsils was not even. No calculation of sampling errors for these estimates was attempted in view of the high sampling errors for these estimates was attempted in view of the high sampling

errors obtained in the earlier pilot survey. The results for these categories of livestock are presented in Table XII.

In Table XIII are presented estimates of agricultural implements. Ploughs, carts and harrows were estimated at 35,280; 49,800 and 58,220 respectively. In the category of ploughs, iron ploughs constituted 12 per cent. There was one plough for every 3.5 draught cattle and one cart per every 2.5 draught cattle. The formula used in estimating draught cattle was the same as mentioned in the Etawah survey. It is interesting to note that unlike Etawah where ploughs far outnumbered carts, the latter were somewhat more numerous than ploughs in Wardha district. Further, it was estimated that there were about 4 ploughs per 100 acres of net area sown as against 18 in Etawah.

From the point of view of cultivators' economy it would be useful to note that the number of working bulls and bullocks constituted 95 per cent of cattle above 3 years in the district and closely of the same order in the individual tehsils too (Table XVII). But large variation was noticed in the numbers of milking animals in tehsils at the time of the survey, the overall percentage of milch cattle being 26 per cent in the district. The values for tehsils Arvi, Wardha, Hinganghat were 32, 29 and 17 per cent, respectively.

Sample Size. With the data collected, efficiencies of different modes of stratification were studied and the optimum level of sampling for households, which constitute secondary units was determined. These investigations are described in Chapter 4. It was seen that size stratification was the most efficient and that 20 households selected in four clusters of five consecutive houses would be advantageous. Despite the efficiency of size stratification as based on number of households per village, it would not be a practicable proposition in large scale sample surveys since it involves knowledge of a number of houses for all villages covered by survey. It would, however, be possible to use some other measure of size, *viz.*, human population for stratification of villages and the present results indicate that such stratifiction would be efficient.

The true variances between households, and between villages were calculated. It was found that the former was nine times the latter. This result was similar to that obtained in the earlier survey in Etawah district.

In Table XIX are presented the numbers of villages to be selected with different number of households per village for varying levels of precision for estimating the cattle population. This study was confined to cattle, as they constitute about 90 per cent of the bovine population in the district using the number of households in the village as an auxiliary variate. The results show that 1419 villages are required to

be selected to estimate the cattle population with 2 per cent sampling error when 20 households are selected within each village. It may be recalled that the corresponding figure in case of Etawah survey, for same level of precision and sub-sampling, for estimating bovine population is 1882 villages. It can be seen that in both the surveys the reduction in the number of villages to be selected is not appreciable beyond 20 households, which may for that reason, be the appropriate number for enumeration at the secondary stage.

The Wardha survey served as a landmark in the evolution of the sampling technique. It confirmed the earlier findings in regard to the feasibility of adopting sampling methods for the purpose of estimating the totals of major categories of livestock namely, cattle, buffaloes and bovines and in regard to the relative importance of the different components of variation. It further revealed the fact that size stratification of village by houses is more efficient than tehsil-wise stratification, and indicated the importance of adopting such stratification in addition to that by administrative units, the latter being necessary for operational conveniences.

The conclusions derived from the two district surveys needed verification under a wider range of conditions before the sampling techniques evolved could be recommended for large scale adoption. For this reason the survey over the entire Bombay State comprising of 28 districts was carried out.

BOMBAY SURVEY

Estimates of Cattle, Buffaloes and Bovines. Table XVIII presents estimated numbers of bovines, cattle and buffaloes for each of the four natural divisions into which the area covered can, as mentioned already, be divided. The number of bovines for the state was etimated at 17.9 millions of which cattle constituted 74 per cent and the rest were buffaloes. Considering the distribution of bovines, the Gujerat area accounted for the highest percentage of bovines (37 per cent) followed by Deccan (30 per cent), Karnatak (18 per cent) and Konkan (15 per cent). Although this is the relative order of importance of the areas in regard to bovine numbers, the estimated densities per square mile present a somewhat different picture, the respective values being 199, 141, 113 and 175. Over the state as a whole, the estimated density of bovines was 165 per square mile and 497 per 1000 persons. The corresponding figures for the 1951 census were 144 and 450, respectively.

The pattern of distribution of cattle and buffaloes among the divisions was not same. For cattle, Deccan and Gujerat were the most important accounting for 35 and 31 per cent of the cattle in the state

while for buffaloes Gujerat and Karnatak possessed 54 and 24 per cent respectively. Census figures of 1951 presented a similar picture.

It may be noted that in the Gujerat area, the percentage increase in cattle number over 1951 census figure was 9 as against 30 in regard to buffaloes. In Konkan and Deccan, the increase in cattle were 27 and 11 per cent respectively and small decrease in buffaloes. It appears that in Karnatak, increase in cattle was balanced by decrease in buffaloes.

In Table XVIII sampling errors of the survey estimates are also presented. The estimates of bovines, cattle and buffaloes were associated with sampling errors of 2.3 per cent, 2.2 per cent and 3.6 per cent respectively. The division-wise estimates had sampling errors varying from 2.8 to 5.9 for bovines; from 3.2 to 6.1 for cattle and from 6.4 to 10.6 for buffaloes.

District-wise estimates were attendant with high percentage sampling errors ranging from 25.8 for cattle up to 62.7 for buffaloes. The sampling fraction of the ultimate unit (i.e., of household in a village) in the district varied from 0.3 per cent to 0.8 per cent, while for the state as a whole, it was 0.4 per cent. The very small sampling fraction was the reason for the high standard errors at the district level. It may be remembered in this connection, that the present state-wide survey was planned to provide adequately precise estimates for divisions and the State as a whole.

In Table XXIV are given the census figures for cattle, buffaloes and bovines of 1945 and 1951, along with the survey estimates. The figures for 1945 are those obtained after adjusting them as far as possible to 1951 administrative set up of the Bombay State. It can be seen from Table XXIV that in 1951, an increase of 17.7 per cent was recorded in cattle over the 1945 census. The estimated figures from the 1954 survey for cattle and buffaloes were 11.1 per cent and 11.3 per cent more than those of 1951. On the assumption that annual increase is uniform, the rates of increase during 1945-51 and 1951-54 in respect of cattle were consistent while those for buffaloes were not. A similar phenomenon was noticed with the results of the Wardha survey, already described.

Bovines recorded 13.7 per cent increase in 1951 over those in 1945 while in 1954 they were 11.1 per cent more than in 1951. Again, the rates of increase were consistent with each other.

Classification. Table XX gives the estimates of bovines, cattle and buffaloes for rural and urban areas separately. Of the total bovines numbering 17.9 million, 2.4 million were found in urban areas. Of the total number of bovines in the rural areas about 76 per cent was accounted for by cattle whereas in the urban areas this figure was 64

per cent. Individual increases over 1951 in rural and urban areas cannot be assessed since separate figures for the two areas were not readily available for the 1951 census.

Table XXI presents the results of classification of the estimated bovine population by age and sex. Among cattle the three age groups, *viz.*, above 3 years, between 1 year and 3 years and below 1 year constituted 75, 16 and 9 per cent respectively ; for buffaloes, the values were 62, 22 and 15 per cent. The corresponding census figures for 1951 were 75, 16 and 9 for cattle and 66, 20 and 14 for buffaloes It should be noted that females among cattle and buffaloes over 3 years constituted 29 per cent and 54 per cent of their respective totals, as against the 1951 census figures of 29 and 59 per cent. Agreement of the estimated percentages with those of the census is indeed very close. The higher percentage of females among buffaloes is due to the animals being kept for milk and not for work except in non-rice growing regions of the State like Konkan.

It seems that male cattle are preferred to male buffaloes in the other divisions. In Konkan, their numbers were evenly divided. For the whole State, males constituted 47 per cent among cattle and 8 per cent among buffaloes. This phenomenon has been noted in the other two surveys in Etawah and Wardha districts also which are located in wheat growing areas of India.

The number of animals in milk at the time of the survey expressed as percentages of total cattle and buffaloes over 3 years, were 32 and 39 respectively.

The percentage sampling errors of males and females of cattle above 3 years and for the young stock (1-3 years and below one year) were respectively 3.2, 3.8 and 3.9 while for buffaloes they were 13.9, 6.6 and 6.3. As mentioned earlier, the sampling errors for total number of buffaloes were 2.2 and 3.6 respectively. It is thus seen that for the estimates under the sub-heads of cattle the sampling errors were slightly higher than that for the total. But the errors for similar categories of buffaloes are nearly double that for the total. This can be explained by the fact that female buffaloes over three years constitute only small percentage namely 12 per cent in the state. The results of the present survey prove conclusively that estimates of numbers under sub-heads in major classes (i e., cattle, buffaloes and bovines) can be obtained with reasonable precision, along with totals.

Breeding Bulls and Working Bulls. The schedules of the survey described above provided for recording data under further sub-divisions among male cattle and buffaloes above 3 years, namely, breeding bulls, working bulls and bullocks not in use for breeding or work and others. It was found on the examination of the returns in the Bombay survey

that the number of cattle in the last two categories was negligible. The percentages of the other two categories to total male cattle above 3 years were estimated. Breeding bulls and working bulls or bullocks constituted 2 per cent and 98 per cent respectively. In absolute terms, the estimates were 1.3 lakhs and 60.5 lakhs respectively. The corresponding percentage figures obtained for 1951 census were 1.7 per cent and 97.0 per cent.

Agricultural Implements. The estimates for agricultural implements, poultry, goats, sheep and horses and ponies for rural and urban areas, are given separately in Tables XXII and XXIII.

The number of carts, wooden ploughs, and iron ploughs were estimated at 16, 38 and 4 lakhs respectively. Gujerat area accounted for the major portion of carts (31 per cent) and ploughs (wooden and iron) (49 per cent) and Konkan the least (13 and 9 respectively). This is understandable since Gujerat area had the highest number of bovines and Konkan the least.

The ratio of ploughs and carts to draught cattle for the state were estimated at five ploughs and two carts for every three animals. The number of draught animals has been calculated by the formula mentioned earlier. It was found that there were about 10 ploughs per 100 acres of net area sown.

Poultry, Sheep and Goats. Total poultry (Table XXIII) in the state were estimated at 86 lakhs of which the rural part constituted 83 per cent and the urban part 17 per cent. Konkan and Deccan together accounted for 66 per cent of the total. Konkan had the highest number, 31 lakhs. The pattern of distribution for poultry is not the same as for bovines. Konkan was found to be the most important for poultry as Gujerat was for bovines. The increase in poultry over 1951 census figure was 38.5 per cent.

The total estimate for sheep for the State was 1.6 lakhs, the rural and urban parts accounting respectively for 91 per cent and 9 per cent. It is interesting to note that Konkan contributed nil, this being associated with heavy rainfall in this region. Karnatak and Deccan gave 6.0 and 5.7 lakhs respectively. Comparing the estimates with those of 1951 census, there was decrease in the number of sheep to the extent of 38 per cent in 1954. Again, the pattern of distribution of sheep was not the same as either of poultry or of bovines.

The number of goats was estimated at 5 lakhs. Deccan and Gujerat appear to be the regions of concentration for goats in the state. Konkan contributed the least number. The goats registered an increase of about 15 per cent over 1951. It is to be expected that Konkan, the highest rainfall area in the state, should rear the least number of sheep and goats while Deccan, Karnatak

and Gujerat are medium rainfall regions and are, therefore, suitable, for goats and sheep. The number of horses was estimated at 2 lakhs registering an increase of about 57 per cent over 1951 census.

The study on sample size for this survey is discussed in Chapter 4.

TABLE III—ESTIMATED NUMBERS OF CATTLE, BUFFALOES AND BOVINES WITH THEIR SAMPLING ERRORS IN PILOT SAMPLE SURVEY IN ETAWAH DISTRICT (1951)

Tehsil	CATTLE			BUFFALOES			BOVINES		
	Estimated No. in '00	Sampling error in '00	Percentage S.E.	Estimated No. in '00	Sampling error in '00	Percentage S.E.	Estimated No. in '00	Sampling error in '00	Percentage S.E.
Etawah	469	49	10.5	701	69	9.8	1170	114	9.7
Bharthana	719	115	15.9	796	94	11.8	1515	194	12.8
Bidhuna	700	86	12.3	746	96	12.9	1446	178	12.3
Auraiya	502	54	10.7	553	40	7.3	1055	86	8.2
District	2390	160	6.7	2796	156	5.6	5186	299	5.8

TABLE IV—ESTIMATED NUMBER OF CATTLE AND BUFFALOES ACCORDING TO

Tehsil	CATTLE										
	Males above 3 years			Female above 3 years			Youngstock (1 to 3 years)			Calves under one year	
	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.
Etawah	224	11.5	47.8	124	10.9	26.5	66	12.1	14.1	54	11.5
Bharthana	311	14.7	43.3	186	17.8	25.9	131	17.7	18.2	91	19.9
Bidhuna	247	12.2	35.2	245	12.5	35.0	119	19.1	17.0	89	15.9
Auraiya	222	10.1	44.2	141	13.9	28.1	71	9.8	14.2	68	15.9
District	1004	6.4	42.0	696	7.3	29.1	387	7.5	16.2	302	8.7

AGE AND SEX AND THEIR SAMPLING ERRORS IN ETAWAH DISTRICT (1951)

	BUFFALOES											
	Males above 3 years			Females above 3 years			Youngstock (1 to 3 years)			Calves under 1 year		
Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle	Estimate in '00	Percentage S.E.	Percentage of Total cattle
11.6	176	11.4	25.1	304	9.3	43.5	99	15.2	1 .2	121	9.5	17.3
12.7	180	17.0	22.7	311	12.7	39.0	144	13.0	18.1	161	12.0	20.2
12.8	264	16.4	35.4	273	11.3	36.6	94	12.0	12.5	116	12.9	15.5
13.5	149	10.9	27.0	211	8.0	38.1	89	9.4	15.5	107	8.6	19.4
12.7	769	7.7	27.5	1099	5.5	39.3	423	6.6	15.1	505	5.7	18.1

TABLE V—COMPARISON OF ESTIMATES GIVEN BY INSPECTORS

Category	Cattle			Buf-
	Enumerators' estimate	Inspectors' estimate	Percentage over (+) or under (—) estimation of (2) over (3)	Enumerators' estimate
1	2	3	4	5
Males over 3 years	376	354	+ 6.2	284
Females over 3 years	298	288	+ 3.5	391
Young stock between 1 and 3 years	103	129	—20.2	170
Calves under one year	132	235	—43.8	166
Total	909	1006	— 9.6	1011

Note : The estimates are for 639 households

TABLE VI—COMPARISON OF SURVEY ESTIMATES WITH THOSE GIVEN BY PATWARI AGENCY IN ALL-INDIA CENSUS, 1951 (DISTRICT ETAWAH, 1951)

		Survey estimate in '00	Census estimate in '00	Percentage excess (+) or decrease (—) of census over survey	Percentage S.E. of the survey estimate
Cattle	Males over 3 years	1004	1011	+ 0.7	6.4
	Females over 3 years	696	746	+ 7.2	7.3
	Young stock between 1 and 3 years	387	456	+17.8	7.5
	Calves under one year	302	387	+28.1	8.7
	Total	2390	2600	+ 5.7	6.7
Buffaloes	Males over 3 years	769	777	+ 1.0	7.7
	Females over 3 years	1099	1169	+ 6.4	5.5
	Young stock between 1 and 3 years	423	375	—11.3	6.6
	Calves under one year	505	432	—14.5	5.7
	Total	2796	2754	— 1.5	5.6
	Total bovines	5186	5354	+ 3.2	5.8

AND ENUMERATORS (DISTRICT ETAWAH, 1951)

faloes		Bovines		
Inspectors' estimate	Percentage over (+) or under (—) estimation of (5) over (6)	Enumerators' estimate	Inspectors' estimate	Percentage over (+) or under (—) estimation of (8) over (9)
6	7	8	9	10
280	+1.4	660	634	+ 4.1
420	– 6.9	689	708	— 2.7
164	+3.7	273	293	— 6.8
159	+4.4	298	394	—24.4
1023	—1.2	1920	2029	— 5.4

in 15 villages and are enumerated independently.

TABLE VII—COMPARISON OF THE SURVEY ESTIMATES FOR SHEEP, GOATS, HORSES AND PONIES AND AGRICULTURAL IMPLEMENTS WITH THOSE OF ALL-INDIA LIVESTOCK CENSUS, 1951 (DISTRICT ETAWAH, 1951)

	Survey estimate (in '00)	Census estimate (in '00)	Percentage excess (+) or decrease (—) of census over survey	Percentage S.E. of survey estimates
Sheep	124	130	+ 4.8	20.7
Goats	1177	1028	—12.7	7.7
Horses and ponies	89	61	—31.5	10.3
Desi ploughs	1044	1008	— 3.4	5.6
Improved ploughs	125	140	+12.0	9.5
Carts	228	235	+ 3.1	7.8

TABLE VIII—ESTIMATED NUMBERS OF CATTLE, BUFFALOES AND BOVINES WITH THEIR SAMPLING ERRORS IN PILOT SAMPLE SURVEY IN ETAWAH DISTRICT (1951)

Tehsil	CATTLE			BUFFALOES			BOVINES		
	Estimated No. in '00	Sampling error in '00	Percentage S.E.	Estimated No. in '00	Sampling error in '00	Percentage S.E.	Estimated No. in '00	Sampling error in '00	Percentage S.E.
Etawah	469	49	10.5	701	69	9.8	1170	114	9.7
Bharthana	719	115	15.9	796	94	11.8	1515	194	12.8
Bidhuna	700	86	12.3	746	96	12.9	1446	178	12.3
Auraiya	502	54	10.7	553	40	7.3	1055	86	8.2
District	2390	160	6.7	2796	156	5.6	5186	299	5.8

TABLE IX—ESTIMATED TOTAL NO. OF CATTLE, BUFFALOES AND BOVINES WITH THEIR SAMPLING ERRORS (DISTRICT WARDHA, 1953)

Tehsil	Cattle			Buffaloes			Bovines	
	Estimated total in '00	Percentage sampling error	Percentage Cattle of total Bovines	Estimated total in '00	Percentage sampling error	Percentage buffaloes of total Bovines	Estimated total in '00	Percentage sampling error
Arvi	1128	7.2	85.2	196	14.8	14.8	1324	7.4
Wardha	1378	9.2	88.2	185	16.8	11.8	1563	9.2
Hinganghat	1121	5.8	92.0	98	7.1	8.0	1219	5.6
District	3627	4.5	88.3	479	9.2	11.7	4106	4.6

TABLE X—ANALYSIS OF VARIANCE OF NUMBER OF LIVESTOCK PER HOUSEHOLD
(DISTRICT ETAWAH, 1951)

	Between tehsils		Between villages		Between households		True variance between villages
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	
CATTLE							
Etawah			55	33.01	6488	2.65	0.29
Bharthana			39	94.46	6191	3.66	0.63
Bidhuna			52	41.48	6276	3.76	0.35
Auraiya			53	49.71	4238	4.24	0.63
District	3	281.84	199	51.71	23193	3.51	0.46
BUFFALOES							
Etawah			55	33.49	6488	2.53	0.29
Bharthana			39	27.90	6191	2.74	0.19
Bidhuna			52	22.97	6276	2.82	0.20
Auraiya			53	10.59	4238	2.55	0.13
District	3	26.32	199	23.54	23193	2.67	0.21
TOTAL BOVINES							
Etawah			55	93.56	6488	6.45	0.81
Bharthana			39	108.08	6191	7.71	0.72
Bidhuna			52	92.83	6276	8.60	0.79
Auraiya			53	51.79	4238	7.87	0.66
District	3	391.39	199	85.20	23193	7.63	0.76

TABLE XI—NUMBER OF VILLAGES TO BE SELECTED WITH DIFFERENT NUMBER OF BUFFALOES AND BOVINES FOR DIFFERENT

M \ λ	CATTLE 2	CATTLE 4	CATTLE 6	CATTLE 8	CATTLE 10	BUF- 2	BUF- 4
10	3156 (1284)	789 (321)	351 (143)	197 (80)	126 (51)	1859 (512)	465 (128)
15	3005 (1154)	751 (288)	334 (128)	188 (72)	120 (46)	1779 (432)	445 (108)
20	2930 (1089)	733 (272)	325 (121)	183 (68)	117 (44)	1738 (391)	434 (98)
25	2892 (1050)	723 (262)	321 (117)	181 (66)	116 (42)	1714 (367)	428 (92)
All households	2754 (929)	689 (232)	306 (103)	172 (58)	110 (37)	1639 (292)	410 (73)

N.B. The figures in brackets indicate the number of villages to be selected households as the

TABLE XII—ESTIMATED TOTAL NUMBER OF SHEEP, GOATS AND POULTRY (DISTRICTS WARDHA, 1953)

Tehsil	SHEEP Males	SHEEP Females	SHEEP Under 1 year	SHEEP Total	GOATS Males	GOATS Females	GOATS Under 1 year	GOATS Total	Poultry
Arvi	387	2738	1277	4402	547	8434	8263	17244	43556
Wardha	182	1745	954	2881	1433	17522	15599	34554	40803
Hinganghat	106	1351	438	1895	794	10100	8198	19092	28253
District	675	5834	2669	9178	2774	36056	32060	70890	112612
1950-51 Census figure				7565				52144	76982

HOUSEHOLDS (M) PER VILLAGE FOR ESTIMATING CATTLE, LEVELS OF PRECISION (δ) (ETAWAH DISTRICT 1951)

FALOES			BOVINES				
6	8	10	2	4	6	8	10
206 (57)	116 (32)	93 (26)	1986 (530)	496 (132)	221 (59)	124 (33)	99 (26)
197 (48)	111 (27)	89 (21)	1917 (466)	479 (116)	213 (52)	120 (29)	96 (23)
193 (43)	109 (24)	87 (19)	1882 (434)	470 (108)	209 (48)	118 (27)	94 (2[illegible])
190 (41)	107 (23)	86 (18)	1862 (415)	465 (104)	207 (46)	116 (26)	93 (21)
182 (32)	102 (18)	82 (15)	1798 (356)	449 (89)	200 (39)	112 (22)	90 (18)

when ratio method of estimation is employed taking the number of auxiliary variate.

TABLE XIII—ESTIMATED TOTAL NUMBER OF DIFFERENT AGRICULTURAL IMPLEMENTS (DISTRICT WARDHA, 1953)

Tehsil	Ploughs			Harrows	Carts	Others
	Wooden	Iron	Total			
Arvi	7517	982	8499	15383	14043	22744
Wardha	11130	1935	13065	21742	23866	53191
Hinganghat	12724	992	13716	21095	11890	25045
District	31371	3909	35280	58220	49799	100980

TABLE XIV—COMPARISON OF SURVEY ESTIMATES OF CATTLE AND BUFFALOES WITH CENSUS FIGURES FOR YEAR 1950-51 AND 1951-52 (DISTRICT WARDHA, 1953)

	Census figures (in '00)		Survey estimate (in '00)	Percentage S.E. of survey estimate
	1950-51	1951-52		
Cattle	3340	3542	3627	4.5
Buffaloes	386	392	479	9.2
Bovines	3726	3934	4106	4.6

TABLE XV—ESTIMATED TOTAL NUMBER OF CATTLE ACCORDING TO AGE AND SEX WITH THEIR SAMPLING ERRORS (DISTRCIT WARDHA, 1953)

	Arvi		Wardha		Hinganghat		District	
	Estimated total in '00	Percentage S.E.	Estimated total in '00	Percentage S.E.	Estimated total in '00	Percentage S.E.	Estimated total in '00	Percentage S.E.
Cattle above 3 years								
Male	342	7.8	490	9.9	398	5.8	1230	4.9
Female	423	8.0	453	8.7	342	6.6	1218	4.6
Cattle young stock between 1 and 3 years								
Male	97	7.2	140	11.4	130	7.7	367	5.5
Female	113	7.2	150	11.0	131	6.7	394	5.2
Cattle calves under one year	153	7.8	145	9.6	120	6.1	418	4.7
Total cattle	1128	7.2	1378	9.2	1121	5.8	3627	4.5
Total buffaloes	196	14.8	185	16.8	98	7.1	479	9.2
Total bovines	1324	7.4	1563	9.2	1219	5.6	4106	4.6

TABLE XVI—ESTIMATES OF CATTLE CALCULATED FROM INSPECTORS' SAMPLE WITH PERCENTAGE SAMPLING ERRORS (DISTRICT WARDHA, 1953)

		No. of villages	No. of villages sampled	Percentage sampling fraction of villages	Estimated total in '00	Percentage sampling error
Size I	Arvi	127	4	3.1	250	57.6
	Wardha	86	3	3.5	79	36.4
	Hinganghat	123	3	2.4	339	42.2
	District	336	10	3.0	668	30.7
Size II	Arvi	109	4	3.7	378	25.8
	Wardha	121	5	4.1	416	17.6
	Hinganghat	103	3	2.9	405	13.2
	District	333	12	3.6	1199	11.1
Size III	Arvi	81	9	11.1	438	18.5
	Wardha	115	9	7.8	560	20.3
	Hinganghat	63	8	12.7	372	19.8
	District	259	26	10.0	1370	11.5
	Total	928	48	5.2	3237	9.0

TABLE XVII—PERCENTAGE OF WORKING BULLS AND BULLOCKS ABOVE 3 YEARS TO THE TOTAL AND PERCENTAGE OF COWS IN MILK TO THE TOTAL AT THE TIME OF SURVEY (DISTRICT WARDHA, 1953)

Tehsil	Percentage working bulls and bullocks to the total male cattle above 3 years	Percentage milk cow to the total number of cows above 3 years
Arvi	95.8	31.5
Wardha	95.5	27.8
Hinganghat	93.1	16.5
District	94.8	25.9

TABLE XVIII—DIVISIONWISE ESTIMATES OF BOVINES, CATTLE AND BUFFALOES

Division	Bovines			Cattle	
	Estimated number in '00	Percentage S.E. of the estimate	Percentage increase over '51 census figure	Estimated number in '00	As percentage total of bovines
1	2	3	4	5	6
Gujerat	65871	3.8	+16.3	40906	62.1
Konkan	27237	5.9	+22.1	23097	84.8
Deccan	53726	5.1	+ 8.8	46741	87.0
Karnatak	31791	2.8	— 0.1	21617	68.0
State	178625	2.3	+11.6	132361	74.1

TABLE XIX—NUMBER OF VILLAGES TO BE SELECTED WITH DIFFERENT NUMBERS OF HOUSEHOLDS (m) PER VILLAGE FOR ESTIMATING CATTLE FOR DIFFERENT LEVELS OF PRECISION (ϵ) (DISTRICT WARDHA, 1953)

ϵ/m	2 per cent	4 per cent	6 per cent	8 per cent	10 per cent
10	2050	512	228	128	82
15	1631	408	181	102	65
20	1419	355	158	90	57
25	1295	324	144	81	52
All households	902	225	100	56	36

TOGETHER WITH THEIR SAMPLING ERRORS (BOMBAY STATE, 1954)

		Buffaloes			
Percentage S.E. of the estimate	Percentage increase over '51 census figure	Estimated number in '00	As percentage total of bovines	Percentage S.E. of the estimate	Percentage increase over 1951 census figure
7	8	9	10	11	12
3.2	+ 9.3	24965	37.9	8.1	+30.1
6.1	+27.3	4140	15.2	10.3	— 0.8
3.7	+11.3	6985	13.0	10.6	— 5.6
4.2	+ 0.8	10174	32.0	6.4	— 0.8
2.2	+11.2	46264	25.9	3.6	+12.5

TABLE XX—DIVISIONWISE ESTIMATES OF BOVINES, CATTLE AND BUFFALOES, TOGETHER
(BOMBAY

Divisions	RURAL					
	Bovines		Cattle		Buffaloes	
	Estimate total in '00	Percentage S.E. of the estimate	Estimate total in '00	Percentage S.E. of the estimate	Estimate total in '00	Percentage S.E. of estimate
Gujerat	57452	3.3	37057	3.8	20395	6.1
Konkan	23043	6.2	19587	7.0	3456	10.8
Deccan	47234	3.4	41802	3.6	5432	10.6
Karnatak	26768	3.8	18497	4.5	8271	7.0
State	154497	2.0	116943	2.3	37594	4.1

TABLE XXI—DIVISIONWISE ESTIMATED PERCENTAGES FOR DIFFERENT

Division	CATTLE					
	Total Cattle in '00	Males over 3 years	Females over 3 years		Young stock	
			Total	In milk expressed as percentage of the females over three years	Between 1 and 3 years	Below 1 year
1	2	3	4	5	6	7
Gujerat	40850	52.2	23.3	36.1	16.7	7.8
Konkan	23096	41.5	32.6	42.6	15.3	10.6
Deccan	46744	44.2	31.7	24.0	15.6	8.5
Karnatak	21634	47.6	26.6	30.5	16.0	9.8
State	132324	46.7	28.7	32.0	16.0	8.9

WITH THEIR SAMPLING ERRORS SEPARATELY FOR RURAL AND URBAN AREAS STATE, 1954)

URBAN

Bovines		Cattle		Buffaloes	
Estimate total in '00	Percentage S.E. of the estimate	Estimate total in '00	Percentage S.E. of the estimate	Estimate total in '00	Percentage S.E. of the estimate
8419	7.4	3847	13.3	4572	7.9
4194	6.3	3510	7.5	684	2.5
6492	20.1	4914	24.8	1578	30.1
5023	9.3	3129	11.6	1894	15.5
24128	6.4	15400	9.1	8728	7.6

CATEGORIES OF CATTLE AND BUFFALOES (BOMBAY STATE, 1954)

BUFFALOES

Total buffaloes in '00	Males over 3 years	Females over 3 years		Young stock	
		Total	In milk expressed as percentage of the females over three years	Between 1 and 3 years	Below 1 year
8	9	10	11	12	13
25024	1.6	53.5	42.6	27.3	17.6
4142	41.0	40.3	34.2	11.4	77.3
6981	10.7	60.3	30.5	16.3	12.7
10157	8.8	56.8	39.1	18.9	15.5
46304	8.3	54.0	39.1	22.3	15.4

TABLE XXII—DIVISIONWISE ESTIMATE OF CARTS, PLOUGHS (WOODEN AND

Division	Rural			Urban
	Carts (in '00)	Ploughs, wooden (in '00)	Ploughs, iron (in '00)	Carts (in '00)
1	2	3	4	5
1. Gujerat	3678	17788	52	1374
2. Konkan	1055	4477	212	359
3. Deccan	6148	4607	2068	716
4. Karnatak	2286	7529	865	464
State	13167	34401	3197	2913
Percentage increase over 1951 census figure				

TABLE XXIII—DIVISIONWISE ESTIMATES OF HORSES, GOATS, SHEEP AND

Division	Rural				Urban
	Horses (in '00)	Goats (in '00)	Sheep (in '00)	Poultry (in '00)	Horses (in 00)
1	2	3	4	5	6
Gujerat	687	12218	3745	14813	72
Konkan	25	2518	0	25193	23
Deccan	819	21058	4743	20759	76
Karnatak	303	7182	5704	10657	45
State	1834	42976	14192	71422	216
Increase over 1951 census figure					

IRON) FOR RURAL AND URBAN AREAS SEPARATELY (BOMBAY STATE, 1954)

Urban		Rural+Urban		
Ploughs, wooden (in '00)	Ploughs, iron (in '00)	Carts (in '00)	Ploughs, wooden (in '00)	Ploughs, iron (in '00)
6	7	8	9	10
2504	98	5052	20292	150
676	0	1414	5153	212
330	283	6864	4937	2351
478	113	2750	8007	978
3988	494	16080	38389	3691
		+49.5	+62.4	+69.6

POULTRY FOR RURAL AND URBAN AREAS SEPARATELY (BOMBAY STATE, 1954)

Urban			Rural+Urban			
Goats (in '00)	Sheep (in '00)	Poultry (in '00)	Horses (in '00)	Goats (in '00)	Sheep (in '00)	Poultry (00' in)
7	8	9	10	11	12	13
1700	193	2432	759	13918	3938	17245
1105	0	5835	48	3623	0	31028
2671	938	4788	895	23729	5681	25547
661	263	1211	348	7843	5967	11868
6137	1394	14266	2050	49113	15586	85688
			+56.8	+14.6	—38.0	+38.5

TABLE XXIV—COMPARISON OF CATTLE, BUFFALOES AND BOVINES WITH CENSUS FIGURES OF 1945 AND 1951 (BOMBAY STATE, 1954)

	1945* (in '00)	1951 (in '00)	Percentage increase (+) or decrease (—) of (2) over (1)	Survey estimates	Percentage increase(+ or decrease (—) of (4) over (2)
	1	2	3	4	5
Cattle	101210	119153	+17.7	132324	+11.1
Buffaloes	40203	41620	+ 3.5	46304	+11.3
Bovines	141413	160773	+13.7	178628	+11.1

* Source : Indian Livestock Census, 1951 Vol. II.

CHAPTER IV

INVESTIGATIONS

The evolution of a sampling technique involves a good deal of study from the points of cost, convenience, and efficiency of statistical design. A proper balance of these factors will lead to a design that can be recommended to the States for routine adoption.

In India, the hierarchy of administrative units is district, tehsil or taluka and village. These constitute compact distinct physical units, which may readily be adopted as strata or stages of a sampling plan. This procedure renders field-work easy for execution and control with the help of departmental staff. In the pilot surveys conducted in the two districts of Etawah and Wardha, tehsils were considered strata whereas in Bombay State, the district was chosen as a stratum.

It remains to be shown how far the tehsils as strata have increased efficiency. Table XXV presents the sum of squares due to between tehsils, between villages and between households for Etawah survey for the important categories of livestock.

TABLE XXV—ANALYSIS OF VARIANCE FOR CATTLE, BUFFALOES AND BOVINES PER HOUSEHOLD (ETAWAH DISTRICT, U.P., 1951)

	Source of Variation	d.f.	s.s.	m.s.
Cattle	Between tehsils	3	845.52	281.84
	Between villages	199	10290.29	51.71
	Between households	23193	81407.43	3.51
	Total	23395	92543.24	3.95
Buffaloes	Between tehsils	3	78.96	26.32
	Between villages	199	4684.46	23.54
	Between households	23193	61925.31	2.67
	Total	23395	66688.73	2.85
Total Bovines	Between tehsils	3	1174.17	391.39
	Between villages	199	16954.80	85.20
	Between households	23193	176962.59	7.63
	Total	23395	195093.36	8.33

It may be seen that tehsils eliminate a large part of the variation in case of cattle and bovines whereas this is not so for buffaloes. Another mode of stratification which suggests itself from the nature of sampling units is stratification by size of village. In fact, a high correlation can be expected to exist between the number of livestock in a village and size of village as judged by number of households.

The comparison of efficiency of size stratification as against tehsil-wise stratification was made in regard to the pata collected in Wardha district.

The number of villages required for estimating the total cattle population for different levels of precision under the two systems of stratification was calculated and are presented in Table XXVI. The results under the system of tehsil-cum-size stratification and non-stratification are also given for comparison.

TABLE XXVI—NUMBER OF VILLAGES REQUIRED FOR ESTIMATING THE TOTAL CATTLE POPULATION UNDER DIFFERENT SYSTEMS OF STRATIFICATION FOR VARYING LEVELS OF PRECISION (WARDHA DISTRICT, 1953)

System of stratification	Percentage standard error			
	3	4	5	6
No stratification	676	381	244	169
Size stratification	339	192	123	84
Tehsil stratification	462	327	237	177
Tehsil-cum-size stratification	242	155	105	76

It is clear from Table XXVI that size stratification reduced the number of villages required considerably than those required under the tehsil stratification for the same level of precision, while not much difference was noticed between size stratification and tehsil-cum-size stratification. Tehsil stratification does not effect much increase in precision, although it is operationally convenient and desirable. The analysis of variance (Table XXVII) calculated on village totals of cattle showed that tehsils did not differ in the average cattle population per village but villages of different sizes showed large variation in this respect.

TABLE XXVII—ANALYSIS OF VARIANCE ON VILLAGE TOTAL OF CATTLE (WARDHA DISTRICT, 1953)

Source of variation	d.f.	M.S.
Between sizes	2	3998347.7**
Between tehsils	2	19825.2
Remainder	120	50723.7
Total	124	113896.7

* indicates significance at 1 per cent level.

Besides the study conducted from the Wardha data, the investigation was continued in the special survey in Poona district of Bombay State (Table XXVIII) and the relative decrease in variance by size stratification of villages expressed as percentage of the variance without stratification for cattle, buffaloes and bovines was respectively 58 per cent, 21 per cent, and 62 per cent.

TABLE XXVIII—ANALYSES OF VARIANCE FOR NUMBERS OF CATTLE, BUFFALOES AND BOVINES PER HOUSEHOLD (POONA DISTRICT, 1954)

Source of variation	Cattle		Buffaloes		Bovines	
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.
Between size strata	2	219.0	2	32.4*	2	407.0
Within strata	1056	13.8	1056	3.2	1056	22.5
Total	1058	14.2	1058	3.3	1058	23.2

* indicates significance at 1 per cent level.

It may, therefore, be concluded that wherever feasible, stratification by size of villages within a district would be very effective in improving precision. However, this procedure requires the latest list of households for all the villages, which can be had only during years of human census. For all practical purposes, this information collected during the preceding human census could be used. Human population may itself be adopted as a measure of size of village if information on the number of houses is not available.

The next question is to study the use of auxiliary characters in improving the efficiency of estimates. There seem to be three characters highly correlated with livestock numbers namely, agricultural area, geographical area and number of households in a village. In regard to the data collected in the Etawah survey, comparison was made of the increases in precision that the correlated items of ancillary information can effect. Table XXIX gives the results.

It can be seen that out of the three characters, number of households registered the highest increase in precision in regard to the estimates of cattle, buffaloes and total bovines. These gains in precision were respectively 39 per cent, 57 per cent and 56 per cent, as against 33 per cent, 29 per cent and 36 per cent for agricultural area. As mentioned earlier, there is a difficulty in getting an accurate list of households although it may be available during census years. It is in this connection that it is suggested that a revision of list of households of selected villages be carried out before actual initiation of the survey

TABLE XXIX—COMPARISON OF THE DISTRICT ESTIMATES OF TOTAL NUMBER OF ANIMALS OBTAINED THROUGH RATIO METHOD OF ESTIMATION WITH VARIOUS AUXILIARY CHARACTERS (ETAWAH DISTRICT, 1951)

	Simple estimate		Ratio estimate					
			With agricultural area		With geographical area		With no. of households	
	Estimate in '00'	S.E. in '00'	Estimate in '00'	S.E. in '00'	Estimate in '00'	S.E. in '00'	Estimate in '00'	S.E. in '00'
Cattle	2390	160	2354	107	2548	91	—	97
		6.7%		4.5%		3.8%		4.1%
Buffaloes	2796	156	2778	111	3004	135	—	67
		5.6%		4.0%		4.8%		2.4%
Total Bovines	5186	299	5132	191	5552	203	—	133
		5.8%		3.7%		3.9%		2.6%

Note :—Sampling errors were expressed as percentage of the totals obtained through the simple method of estimation. Ratio estimates using number of households as auxiliary variate could not be given since information on total number of households was not available.

itself. If this is not feasible, agricultural area or geographical area may be taken in order of preference as the auxiliary character.

A similar study was carried out from the data of the Wardha survey for the number of households as auxiliary character, since it proved most efficient in the Etawah survey. As already stated, the list of households in each selected village was brought up-to-date. Since cattle constitute the major portion of livestock in Wardha district, the study was confined to cattle alone. For the district total increase in precision of the ratio estimate was of the order of 35 per cent over that of the simple estimate.

In the Poona special survey, the increase in efficiency of the ratio method of estimation with the number of households as the auxiliary character was 30 per cent for cattle.

This confirms that the number of households can be utilised as auxiliary character in effecting a substantial reduction in sampling variance, even after employing size stratification of the villages.

The next question to be considered is the number of households to be selected in any sub-sampling procedure. The study was carried out from the data of the two surveys. Table XXX presents the mean

squares between households.

TABLE XXX—MEAN SQUARES BETWEEN HOUSEHOLDS (CATTLE)

ETAWAH			WARDHA		
Tehsil	d.f.	m.s.	Tehsil	d.f.	m.s.
Etawah	6488	2.65	Arvi	4523	81.20
Bharthana	6191	3.66			
Bidhuna	6276	3.76	Wardha	5318	50.00
Auraiya	4238	4.24	Hinganghat	4225	58.49
District	23193	3.51		14066	62.58

The results indicate that there was a good deal of difference in the order of variations between households in the two districts, thus pointing to widely different conditions. This high order of variation can perhaps be ascribed to the fact that the average number of cattle per household in the Wardha district was two and a half times that in Etawah district. Table XXXI presents the results obtained.

TABLE XXXI—ESTIMATED NUMBER OF CATTLE PER HOUSEHOLD

	ETAWAH				WARDHA		
	Etawah	Bharthana	Bidhuna	Auraiya	Wardha	Arvi	Hinganghat
Average cattle per household	1.1	1.6	1.4	1.6	2.9	5.4	3.8
District Average		1.4				3.5	

The two surveys conducted at the district level made possible the calculations of the number of villages that would be required at different levels of precision, for estimating the number of cattle and total bovines in the two states, of which these districts were considered to be typical. Since cattle constituted the bulk of livestock population in the district of Wardha, results were obtained for cattle only, while in the case of Etawah, since bovines were evenly divided between cattle and buffaloes they were presented for total bovines. The results are presented in the Table XXXII.

It can be seen from Table XXXII that almost the same number of villages was required to be selected in the Madhya Pradesh district and in Uttar Pradesh for the same level of precision and selection of ten

TABLE XXXII—NUMBER OF VILLAGES REQUIRED CORRESPONDING TO VARYING NUMBERS OF HOUSEHOLDS IN SUB-SAMPLE FOR GIVEN LEVELS OF PRECISION

No. of households	WARDHA			ETAWAH		
	2%	4%	6%	2%	4%	6%
10	2050	512	228	1986	496	221
15	1631	408	181	1917	479	213
20	1419	355	158	1882	470	209
All households	902	225	100	1798	449	200

households although a better type of sampling design by stratifying the villages according to sizes was used in the Wardha survey. This indicates that in spite of size stratification substantial variance due to villages persisted. However, by increasing the number of households in Wardha, a smaller number of villages was required to be selected in this district as compared to Etawah. This is to be expected due to the larger variation between households here.

Another important point in this connection is the possibility of selecting households in clusters. Field work in a cluster would be more convenient operationally. This aspect was studied by way of calculating the number of villages that would be necessary under the two modes of selection. The results obtained are given in Table XXXIII.

TABLE XXXIII—NUMBER OF VILLAGES REQUIRED FOR DIFFERENT LEVELS OF PRECISION BY DIRECT AND CLUSTER SELECTION OF HOUSEHOLDS (WARDHA, 1953)

Households	Percentage standard error		
	3	4	5
20 households at random	630	355	227
4 clusters at random of 5 h.h. each	612	344	220

There appears to be definite advantage in selecting the households in form of clusters. In fact number of villages required to be selected for a fixed precision will be less in case of cluster sampling than it is required otherwise. This may be due to the slight negative intra-class correlation coefficient within elements of clusters, which was seen to be of the order of —0.07 for a tehsil. It may, therefore, be said that selection by way of clusters may not be statistically less efficient. It

was precisely for this reason that selection of 20 houses was done in the Bombay survey through clusters of 5 geographically contiguous houses each.

Having thus determined the broad features of the technique, it is necessary to examine it in relation to its application of state-wide surveys. Table XXXIV gives the sample size required for estimating the total bovines in the rural area of the Bombay State. For given number of villages m and number of cluster of houses within a village n values of number of talukas to be selected k, are presented for different values of level of precision λ.

TABLE XXXIV—NUMBER OF TALUKAS TO BE SELECTED FOR DIFFERENT LEVELS OF PRECISION FOR ESTIMATION OF TOTAL BOVINES (a) AND CATTLE (b) AND GIVEN VALUES OF m (VILLAGES PER TALUKA) AND n (NO. OF CLUSTERS PER VILLAGE) (BOMBAY, 1954)

	m=6			m=8			m=10			m=12		
							$\lambda=2$					
n=	2	4	6	2	4	6	2	4	6	2	4	6
k=(a)	259	167	137	194	126	103	155	100	82	129	84	68
(b)	293	193	160	220	145	120	176	116	96	146	97	80
							$\lambda=4$					
n=	2	4	6	2	4	6	2	4	6	2	4	6
k=(a)	65	42	34	48	31	26	39	25	21	32	21	17
(b)	73	48	40	55	36	30	44	29	24	37	24	20
							$\lambda=6$					
n=	2	4	6	2	4	6	2	4	6	2	4	6
k=(a)	29	19	15	21	14	11	17	11	9	14	9	8
(b)	33	21	18	24	16	13	20	13	11	16	11	9

From Table XXXIV it can be seen that for 2 per cent level of precision 824 villages are required for m=8, n=6, against 820 for

m=10 and n=6 and 816 for m=12 and n=6. It may, therefore, be suggested that selection of 68 talukas and 12 villages per selected taluka and 6 clusters per village would be the most appropriate. Under this plan, it would be possible to allot the field work in a taluka to a single enumerator and thereby inter-taluka movments can be avoided, cost of travel reduced and field work would be facilitated. The number of clusters may be increased to 6, since the additional work involved would not be much as it is confined to the selected village. As against 330 houses enumerated by the enumerator in the Bombay survey, the number under the present plan will be 360.

Similar calculation was done in respect of cattle. It can be seen from the Table that the number of villages that would be required for $\lambda=2$, $m=12$, and $n=6$ is 960 as against 816 for total bovines. Therefore, under the scheme of choosing 12 villages per taluka and 6 clusters in a village the major categories of livestock i.e., bovines, cattle, and buffaloes would be estimated with a precision of nearly 2 per cent, 3 per cent and 4 per cent respectively using the number of households per village as auxiliary variate. In any case, it can be said that the categories of livestock can be estimated with reasonable precision.

Some problems relating to methodological aspect from these surveys are discussed in Appendix I.

The series of surveys conducted have thus led to the establishment of a sampling technique which can be utilised for the purpose of providing an independent check of the census figures. The design will be of multi-stage stratified sampling, with talukas as primary sampling units. In states possessing more than 5 million bovine population, selection of 15 to 20 villages and 3 or 4 urban areas in a district depending on its size and 20 occupied households selected in the form of 4 random clusters of 5 consecutive ones each, would result in sampling errors varying from 3 to 5 per cent for categories of cattle, buffaloes and bovines for the state as a whole. The urban areas in each district may be selected with probability proportional to their respective number of households in the latest census with replacement.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The series of pilot surveys conducted in Etawah district of Uttar Pradesh, Wardha district of Madhya Pradesh, and Bombay State have led to the conclusion that sampling can be utilised usefully and successfully for estimating livestock numbers annually. A study of the data collected in these surveys has indicated that the stratification by size of villages (size being defined by total number of households in the villages) is most effective in reducing the sampling variance. Tehsil-wise stratification has not proved very useful in reducing the sampling variance. Hence, wherever it is feasible, stratification by size of villages within a district or taluk, whichever is administratively convenient for field operation, should be adopted.

For the Etawah district, study was also made for a suitable auxiliary variate which could improve the efficiency of the estimate by following the ratio method of estimation. Variates studied were agricultural area of the village, geographical area of the village, and total number of households in the village. It was found that total number of households as auxiliary information is most useful. Next to that was the agricultural area.

The analysis of the Bombay survey has indicated that selection of about 70 taluks and 12 villages per selected taluk and 6 clusters of 5 households each per selected village, which accounts for less than 1 per cent of the total number of households in the state would be the most appropriate design (giving 2 per cent sampling error) to be adopted in any state-wide survey for estimating bovine number. However, this number will slightly increase if estimates are to be obtained for important categories of livestock separately.

Another useful purpose that these sampling enquiries can serve will be rationalising the method of supervision with a view to improve the quality of census data. If during the census year, supervision is organised on a suitable sampling plan, it will serve two purposes, (i) rationalisation of supervision over the field workers engaged in census, and (ii) building up independent estimates of livestock number much more quickly than the census data will provide. It is, therefore, recommended that during the all-India census year, the technique of sampling developed through the surveys reported here may be adopted by the states for improving the quality of census data and for adjustment of census results on the basis of independent estimates. Also, during the inter-census period when the

need of basic data for planning purposes is felt, the technique of sample survey could be easily used for collecting the necessary data without incurring heavy expenditure. A scheme for sample supervision on the census operations based on the present results was prepared by the Council and is given in Appendix V.

Estimation of livestock number is not an end in itself. Further work in this direction will be to evolve suitable sampling techniques in estimating various types of livestock products, such as milk, wool, poultry, etc. Such investigations should be given priority since such statistics of livestock products as are at all available in the country at present are of doubtful reliability.

APPENDIX I

OPTIMUM SAMPLE SIZE

Mention should be made of the results of the methodological research conducted in relation to certain aspects of sample surveys in general and the livestock surveys in particular. The two problems that have been studied are :

Problem I : The relationship between variance of cluster means with the size of the cluster.

Problem II : Optimum choice of sample size and optimum allocation of sampling units over different stages of sampling.

Problem I : In order to determine the optimum size and number of clusters to be sampled for the purpose of estimation of livestock numbers it is necessary to know the change in variance per cluster average with increase in size of cluster. A variance function has to be fitted between the two.

The type of variance function due to Fair-field Smith (1938), namely,

$$V(\bar{x}_n) = \frac{a}{n^b} \qquad \begin{matrix} a>0 \\ b<1 \end{matrix}$$

n = cluster size

$\bar{x}_n$ = sample mean (sample of clusters)

was tried in relation to data in the Wardha survey.

It may be recalled that data for livestock numbers were collected for all households in selected villages. These were grouped into clusters of uniform size by grouping geographically consecutive households. This was done by taking houses together, which were serially numbered in order of geographical contiguity. The total number of clusters was given by the quotient as obtained by dividing the total number of households by the size of cluster. If the size of cluster be n and the quotient be q, the yth cluster ($y<q$) will consist of the following household numbers :

$$\left\{ (y-1)\,n+1,\ (y-1)\,n+2, \qquad \ldots\ldots, ny \right\}$$

The cluster sizes that have been studied are 2, 4, 8 in case of stratum I and 2, 4, 8 and 16 in strata II and III. The analysis of variance giving 'Between clusters' and 'Within clusters' for each village in each stratum was done and pooling was done for all the villages in a stratum. From the true variances obtained from the analyses, the values of

Size of cluster	Stratum Size I			Stratum
	Arvi	Wardha	Hinganghat	Arvi
2	0.06861	0.02779	0.05268	0.16718
4	0.09049	negative	0.02588	0.12052
8	0.05181	0.01832	0.05422	0.09723
16	—	—	—	0.06073
Value of b	0.83614	0.95114	0.87543	0.75808

Size II		Stratum Size III		
Wardha	Hinganghat	Arvi	Wardha	Hinganghat
0.23341	0.12690	0.05823	0.23769	0.21819
0.21500	0.03017	0.03903	0.16429	0.06435
0.08376	0.03680	0.04543	0.11657	0.07591
0.05453	0.04993	0.03256	0.07980	0.05920
0.78903	0.82349	0.85301	0.71769	0.78313

a and b were estimated by least squares method after logarithmic transformation. The values for location and scale parametres, a and b, are given in the following Tables :

Values of a

Tehsil \ Size	I	II	III
Arvi	2.14488	2.02026	1.95077
Wardha	2.09289	1.99149	1.75166
Hinganghat	1.93353	1.80654	1.79878

It is obvious from the Tables that the values of b and a decrease with increase in size except in case of b for Arvi. The closeness of the fit was tested by X^2 and was found to be quite satisfactory.

The value of 'b' is determined by degree of correlation between neighbouring units. The following Table gives the intra-class correlation coefficients, P_n, along with values of b.

Values of b

Tehsil \ Size	I	II	III
Arvi	0.83614	0.75808	0.85301
Wardha	0.95114	0.78903	0.71769
Hinganghat	0.87543	0.82349	0.78313

There is no regular trend in the value of P_n in stratum size I with respect to size of cluster. But in strata size II and III the estimated value of P_n decreases with increase in size of cluster. It is found by trial and error that the relationship between P_n and b is as follows.

$$P_n(n-1) = {}_n1 - b - 1$$

This is an empirical relationship which is applicable to the present populatiou under study but may not be true to others.

Problem II : The optimal values are taken to mean those obtained by minimising variance for given cost. Cost function was built up in terms of time spent for different operations of survey. Breaking up the total time spent into

1. Journey time
2. Enumeration time
3. Time spent in preparing sample frame
4. Time spent in preparatory work,

The function can be expressed, in mathematical notation as :

$$C' = C_0'\sqrt{m} + C'_1 m + C_3' m\sqrt{n} + C_4' mnM$$

Where $C_0' = C''_0\sqrt{\bar{A}}$, $C_3' = C_0''\sqrt{\bar{A}}$

and C' = Total time spent

C_0'' = Time spent in travelling unit distance

A = Area of a region

$\bar{A}$ = Average area of a primary unit

C_1' = Time required in preparing a sample frame for each primary unit

C_4' = Time required in enumerating a single ultimate units

m = Number of primary units selected in the sample

n = Number of secondary units selected within each primary unit consisting of N unit

M = Size of the secondary unit and is assumed to be constant

By dividing the right hand side of the algebraic equation given above by C_4', the cost function can be expressed in a simpler form as follows :

$$C = C_0\sqrt{m} + C_1 m + C_3 m\sqrt{n} + mnM$$

If Y^{-1} is taken as a simple sample average on unit basis, its variance is

$$V(Y^{-1}) = \frac{\sigma_v^2}{m} + \frac{\sigma_w^2}{m}\left(\frac{1}{n} - \frac{1}{N}\right)$$

Where σ_v^2 = Variance between primary unit averages (per ultimate unit basis)

σ_w^2 = Variance (per ultimate unit basis) between secondary units within primary unit

Making use of the fact that σ_w^2 follows the law :

$$\sigma_w^2 = \frac{a}{M^b}$$

Where

$a(=\sigma^2)$ = Total variance between ultimate units

b = regression coefficient of log σ_w^2 on log M

The optimal values of m, n, M which minimse the variance subject

to a fixed cost are given by

$$\sqrt{m} = \frac{-C_0 \pm \left\{ C_0^2 + 4C\left(C_1 + C_3\sqrt{n}\ \frac{2-b}{2(1-b)}\right) \right\}^{\frac{1}{2}}}{2\left(C_1 + C_3\sqrt{n}\ \frac{2-b}{2(1-b)} \right)}$$

$$n = \frac{\sigma w}{\sigma v} \sqrt{\frac{1-b}{C_3}} \left\{ C_3\, n + 2C_1\sqrt{n} + C_0 \sqrt{\frac{n}{m}} \right\}^{\frac{1}{2}}$$

and $M = \dfrac{bC_3}{2(1-b)\sqrt{n}}$

It may be seen that no explicit solutions can be obtained for the optimal values. However, an attempt is made to find out the optimal values by fixing some arbitrary values for C_0, C_1, C_3 and C. The Tables (on page 57) give the values under the overall conditions of 30 working days for a survey in a district of 4,000 sq. miles and 2 sq. miles for each primary unit for 6 and 8 hours working a day and the time taken in listing is one day per village. The comparison of the results, for different enumeration times, i.e., 2, 5, 10 and 15 minutes for a fixed journey time and for same duration of working days, reveals that the number of villages to be selected decreases gradually and correspondingly there is an increase in the number of clusters to be selected within each sampled village.

With the decrease in the number of villages we expect a corresponding reduction in time for travelling between villages as well as preparing frame for each village. This time could be utilized by increasing the number of clusters to be selected within each selected unit. In the same Table, the percentage sampling errors, and the optimum number of households to be sampled are also presented. It will be observed that for the same enumeration time for households, there is a decrease in number of households to be sampled with an increase in time required for travelling a unit mile, followed by the increase in the percentage sampling errors. But for the same journey time, and for different enumeration time we observe a striking fall in the number of households to be sampled accompanied by a small increase in the percentage sampling errors.

These Tables would be useful in planning similar surveys under varied conditions. For livestock surveys enumeration time may be taken as 5 minutes and even under difficult conditions journey time may not be more than 30 minutes. Thus the cluster of five households prove optimum in a survey conducted under the above mentioned conditions.

CALCULATION OF OPTIMUM VALUES OF NUMBER OF VILLAGES, NUMBER OF CLUSTERS AND SIZE OF THE CLUSTERS TO BE SELECTED

6 HOURS WORKING A DAY

Enumeration time per household (in minutes)	2		5		10		15	
Journey time per unit mile (in minutes)	20	30	20	30	20	30	20	30
Villages (m)	11.4	8.6	10.3	7.7	9.3	7.0	8.7	6.6
Clusters (n)	7.3	4.4	14.1	9.0	23.9	15.1	32.3	21.0
Size (M)	9.5	18.3	2.7	5.1	1.1	2.0	0.6	1.1
Variance	0.7643	1.0157	0.9238	1.2099	1.0946	1.4260	1.2189	1.5929
PrecentageS.E.	17.1	19.7	18.8	21.5	20.5	23.3	21.6	24.7
Households	789	695	396	358	233	210	169	154

CALCULATION OF OPTIMUM VALUE OF NUMBER OF VILLAGES, NUMBER OF CLUSTERS AND THE SIZE OF THE CLUSTERS TO BE SELECTED

8 HOURS WORKING A DAY

Enumeration time per household (in minutes)	2		5		10		15	
Journey time per unit mile (in minutes)	20	30	20	30	20	30	20	30
Villages (m)	13.8	11.0	12.5	10.0	11.4	9.0	10.7	8.5
Clusters (n)	8.1	4.8	16.0	9.6	27.0	16.1	37.2	22.6
Size (M)	9.0	17.5	2.6	5.0	1.0	1.9	0.6	1.1
Variance	0.6273	0.7868	0.7452	0.9295	0.8723	1.0822	0.9714	1.2137
PercentageS.E.	15.5	17.3	16.9	18.8	18.3	21.3	19.3	21.5
Households	1005	928	512	475	304	280	222	207

APPENDIX II

PROCEDURES OF ESTIMATION

ETAWAH AND WARDHA SURVEYS

1. In both these surveys the sampling design was one of single stage stratified sampling. Villages were the sampling units within strata.

The procedure of estimating the total number of individuals under any category was as follows.

Let N_i denote the total number of villages in the kth stratum out of which n_i villages were selected and y_{ij} denote the total number of individuals in the jth selected village in the ith stratum. Then the estimate of the total number of individuals in the ith $\hat{T}_i$ given by

$$\hat{T}_i = \frac{N_i}{n_i} \sum_{j=1}^{n_i} y_{ij} = N_i \, \bar{y}_{i.} \qquad \text{.........} \quad (1.1)$$

The variance of this estimate is given by

$$V(\hat{T}_i) = N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i} \right) \sigma^2_{i}v \qquad \text{.........} \quad (1.2)$$

$$\text{where} \quad \sigma^2_{i}v = \frac{1}{N_i - 1} \sum_{j=1}^{N_i} \left(y_{ij} - \bar{y}_i \right)^2$$

The estimates of the variance is given by

$$\hat{V}(\hat{T}_i) = N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i} \right) s^2_{i}v \qquad \text{.........} \quad (1.3)$$

$$\text{where} \quad s^2_{i}v = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} \left(y_{ij} - \bar{y}_{i.} \right)^2$$

Adding each of the expressions (1.1), (1.2) and (1.3) over all strata we obtain the corresponding expressions for the district.

2. When a sub-sampling design is adopted taking the villages as secondary stage sampling units and households as secondary stage sampling units, the estimate for the total number of individuals in the ith stratum will be

$$\hat{T}_i = \frac{N_i}{n_i} \sum_{j=1}^{n_i} \frac{H_{ij}}{h_{ij}} \sum_{k=1}^{h_{ij}} y_{ijk}$$

$$= \frac{N_i}{n_i} \sum_{j=1}^{n_i} H_{ij} \; \bar{y}_{ij} = N_i \bar{y}_{i.} \qquad \text{.........} \quad (1.4)$$

where y_{ijk} is the number of individuals in the kth household of the

jth village in the ith stratum and h_{ij} is the number of households selected out of H_{ij} households in the jth village. The variance of the estimate is given by

$$V(\hat{T}_i) = \frac{N_i(N_i - n_i)}{n_i} \sigma^2{}_i v + \frac{N_i}{n_i} \sum_{j=1}^{N_i} H^2{}_{ij} \left(\frac{1}{h_{ij}} - \frac{1}{H_{ij}}\right) \sigma^2{}_{ijw} \dots \quad (1.5)$$

$$\text{where } \sigma^2{}_{ijw} = \frac{1}{H_{ij}-1} \sum_{k=1}^{H_{ij}} \left(y_{ijk} - \overline{y_{ij\cdot}}\right)^2$$

$$\text{and } \sigma^2{}_i v = \frac{1}{N_i - 1} \sum_{j=1}^{N_i} \left(\overline{y}_{ij\cdot} - \overline{y}_{i\cdot\cdot}\right)^2$$

The estimates of the variance is given by

$$\hat{V}(\hat{T}_i) = \frac{N_i(N_i - n_i)}{n_i} s^2 iv + \frac{N_i}{n_i} \sum_{j=1}^{n_i} H_{ij}{}^2 \left(\frac{1}{h_{ij}} - \frac{1}{H_{ij}}\right) s_{ijw}{}^2 \quad \dots \quad (1.6)$$

$$\text{where } s_{ijw}{}^2 = \frac{1}{h_{ij}-1} \sum_{k=1}^{h_{ij}} \left(y_{ijk} - \overline{y}_{ij}\right)^2$$

$$\text{and } s^2{}_i v = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} \left(\overline{y_{ij\cdot}} - \overline{y_{i\cdot\cdot}}\right)^2.$$

BOMBAY SURVEY

In this survey the design was one of multi-stage stratified random sampling. Districts were treated as strata. The successive stages of sampling units were taluka, village and cluster of occupied houses. At the primary or taluka stage selection was done with replacement with probability proportional to bovine population as obtained during 1951 livestock census. The number of talukas selected in each district was in proportion to its bovine population. Simple random sampling was followed for selecting the units of other stages.

Let y_{ijl} be the number of cattle in the lth house of the jth village of the ith taluka

$$\left\{ (l = 1, 2 \dots n_{ij} \leq 20),\ (j = 1, 2 \dots m_i = 8),\ (i = 1, 2, \dots\dots k). \right\}$$

The estimated total for cattle for the district will be given by

$$\hat{y} = \frac{1}{k} \sum_{i=1}^{k} \frac{1}{P_i} \left\{ x_i \frac{\sum_{j=1}^{m_i} N_{ij} \sum_{l=1}^{n_{ij}} \frac{y_{ijl}}{n_{ij}}}{\sum_{j=1}^{m_i} x_{ij}} \right\} \quad \dots \quad (2.1)$$

Where k = number of talukas selected (including repetitions of the same talukas) selected out of K talukas.

P_i = Probability of selection of the ith taluka

x_i = the total cattle population for the ith taluka as reported in the livestock census, 1951 and is given by $\sum_{j=1}^{M_i} x_{ij}$ (M_i being the number of villages in the ith taluka and x_{ij} the total number of cattle in the jth village of the ith taluka as reported in 1951 livstock census).

N_{ij} = number of occupied houses in the jth village of the ith taluka as given in 1951 census.

n_{ij} = number of occupied houses enumerated in the sample of clusters.

Define

$$\hat{y}_i = x_i \frac{\sum_{j=1}^{m_i} \frac{N_{ij}}{n_{ij}} \sum_{l=1}^{n_{ij}} y_{ijl}}{\sum_{j=1}^{n_i} x_{ij}}$$

$$\therefore \quad \hat{y} = \frac{1}{k} \Sigma \frac{\hat{y}_i}{P_i}$$

Now $V(\hat{y}) = E \left\{ \hat{y} - E(\hat{y}) \right\}^2$

$$= E(\hat{y}^2) - Y^2$$

where $Y = E(\hat{y})$

$$E(\hat{y}^2) = \frac{1}{k^2} E_i \left[\frac{1}{P_i^2} \left\{ V(\hat{y}_i) + E(\hat{y}_i^2) \right\} + \sum_{i \neq i'}^{k} \frac{1}{P_i P_{i'}} \hat{y}_i \hat{y}_{i'} \right]$$

$$V(\hat{y}_i) = \frac{M_i(M_i - m_i)}{m_i} \sum_{j=1}^{M_i} \frac{(y_{ij} - R_i x_{ij})^2}{M_i - 1} + \frac{M_i}{m_i} \sum_{j=1}^{M_i} V(\hat{y}_{ij})$$

$$= \frac{M_i(M_i - m_i)}{m_i(M_i - 1)} \sum_{j=1}^{M_i} (y_{ij} - R_i x_{ij})^2$$

$$+ \frac{M_i}{m_i} \left(\frac{N_{ij}}{5} \right)^2 \left(\frac{5}{n_{ij}} - \frac{5}{N_{ij}} \right) \sum_{1}^{N_{ij}/5} \frac{(y_{ijl} - \bar{y}_{ij})^2}{N_{ij}/5 - 1}$$

where $R_i = \dfrac{\sum_{j=1}^{M_i} y_{ij}}{\sum_{j=1}^{M_i} x_{ij}}$

Define $\sum_{1}^{N_{ij}/5} \frac{(y_{ijl}-\bar{y}_{ij})^2}{N_{ij}/5-1} = \sigma^2_{ijc}$

= mean square between clusters

$$\therefore V(\hat{y}) = \frac{1}{k^2} E_v \left[\sum_{i}^{k} \frac{1}{P_i^2} \left\{ \frac{M_i(M_i-m_i)}{m_i(M_i-1)} \sum_{j=1}^{M_i} (y_{ij}-R_i x_{ij})^2 \right. \right.$$

$$\left. + \frac{M_i}{m_i} \sum_{j=1}^{M_i} C_{ij}^2 \left(\frac{1}{c_{ij}} - \frac{1}{C_{ij}}\right) \sum_{l=1}^{C_{ij}} \frac{(y_{ijl}-\bar{y}_{ij})^2}{C_{ij}-1} + y_i^2 \right\}$$

$$\left. + \sum_{i \neq i'} \frac{1}{P_i P_{i'}} y_i y_{i'} \right] - Y^2$$

where C_{ijd} = number of clusters in the j th village of i th taluka

c_{ij} = number of clusters in the sample

$$\therefore V(\hat{y}) = \frac{1}{k} \left[\sum_{i=1}^{K} \frac{1}{P_i} \left\{ \frac{M_i(M_i-m_i)}{m_i(M_i-1)} \sum_{j=1}^{M_i} (y_{ij}-R_i x_{ij})^2 \right. \right.$$

$$\left. + \frac{M_i}{m_i} \sum_{j=1}^{M_i} C_{ij}^2 \left(\frac{1}{c_{ij}} - \frac{1}{C_{ij}}\right) \sigma^2_{ijc} + y_i^2 \right\}$$

$$\left. + k(k-1) Y^2 \right] - Y^2$$

$$= \frac{1}{k} \left[\sum_{i=1}^{K} \frac{1}{P_i} \left\{ \frac{M_i(M_i-m_i)}{m_i} \sigma^2_{iv} \right. \right.$$

$$\left. \left. + \frac{M_i}{m_i} \sum_{j=1}^{M_i} \left(\frac{1}{c_{ij}} - \frac{1}{C_{ij}}\right) C_{ij}^2 \sigma^2_{ijc} \right\} + \sigma^2_T \right] \quad \text{......(2.2)}$$

where $\sigma^2_{iv} = \frac{1}{M_i-1} \sum_{j=1}^{M_i} (y_{ij}-R_i x_{ij})^2$

$$\sigma^2_T = \Sigma P_i \left(\frac{y_i}{P_i} - Y\right)^2$$

The expression for the variance given in (2.2) can be simplified under the following assumptions:

(i) Neglecting the finite correction factors for houses in a village and villages within a taluka

(ii) $c_{ij}=c$, $n_{ij}=n$ and $m_i=m$

(iii) homogeneity of σ^2_{ijc}'s and σ^2_{iv}'s

$$\therefore V(\hat{y}) = \frac{1}{k} \left[\sigma^2_T + \sum_{1}^{K} \frac{M_i^2}{P_i m_i} \left\{ \sigma^2_{iv} + \frac{1}{M_i} \sum_{j=1}^{M_i} \frac{C^2_{ij}}{c_{ij}} \sigma^2_{ijc} \right\} \right]$$

$$= \frac{1}{k} \left[\sigma^2_T + \frac{\sigma^2 v}{m} \sum_{i=1}^{K} \frac{M^2_i}{P_i} + \frac{\sigma^2_c}{mn} \sum_{i=1}^{K} \frac{M_i}{P_i} \sum_{j=1}^{M_i} N^2_{ij} \right]$$

$$= \frac{\sigma^2_T}{k} + \frac{A\sigma^2 v}{km} + \frac{B\sigma^2_c}{kmn} \quad \ldots\ldots\ldots (2.3)$$

where $A = \sum_{i=1}^{K} \frac{M_i^2}{P_i}$ of which an estimate is

given by $\hat{A} = \frac{1}{k} \sum \frac{M^2_i}{P^2_i}$

and $B = \sum_{1}^{K} \frac{M_i}{P_i} \sum_{1}^{M_i} N^2_{ij}$ of which an estimate is

given by $\hat{B} = \frac{1}{k} \sum_{1}^{k} \frac{M^2_i}{P^2_i} \frac{1}{m_i} \sum_{j=1}^{M_i} N^2_{ij}$

$\hat{\sigma}^2_c = s^2_c =$ pooled mean square between cluster means within villages

$$\hat{\sigma}^2 v = s^2 c - \frac{s^2_c}{m_o} \sum_{i=1}^{k} \sum_{j=1}^{m_i} \frac{N^2_{ij}}{n_{ij}}$$

$$\sigma^2_T = s^2_T - \frac{1}{k} \left[\sum_{1}^{k} \frac{1}{P^2_i} \left\{ \frac{M_i^2}{m_i} s^2 v + \frac{M_i}{m_i} \sum_{1}^{m_i} \frac{N^2_{ij}}{n_{ij}} s^2_c \right\} \right]$$

$$= s^2_T - \frac{1}{k} \left[s^2 v \sum_{1}^{k} \frac{M^2_i}{P^2_i m_i} + s^2 c \, . \sum_{1}^{k} \frac{M_i}{P^2_i m_i} \sum_{1}^{m_i} \frac{N^2_{ij}}{n_{ij}} \right]$$

where $m_0 = \sum_{1}^{k} m_i$

All the above expressions are for a stratum namely, a district. Now we shall obtain for the state.

Let Q_d be the livestock population in a district d in 1951, Q in the state as a whole. Let k_0 be the total number of selected talukas in the State distributed among different districts in proportion to Q_d.

Then, if $\hat{y}_d$ is estimate of the livestock population in a district d, then the estimate for the state is $\sum_{d} \hat{y}_d$, where the summation sign extends over all districts. The expression for the variance of this estimate is

$$V(\Sigma_d \hat{y}_d) = \frac{Q}{k_0} \left\{ \Sigma \frac{\sigma^2_{dT}}{Q_d} + \sum_{d} \frac{A_d \sigma^2_d v}{m_d Q_d} + \Sigma \frac{B_d \sigma_d c}{m_d n_d Q_d} \right\} \ldots\ldots (2.4)$$

Again, assuming (i) the homogeneity of σ^2_{dT}'s, $\sigma^2_d v$'s and σ^2_{dc}'s and (ii) $m_d = m$, $n_d = n$. we obtain

$$V(\sum_{d} \hat{y}_d) = \frac{Q}{k_0} \left\{ S^2_T \sum_{d} \frac{1}{Q_d} + \frac{\sigma^2 v}{m} \sum_{d} \frac{A_d}{Q_d} + \frac{\sigma^2_c}{mn} \sum_{d} \frac{B_d}{Q_d} \right\} \ldots (2.5)$$

The estimate of this variance was obtained by making use of the pooled values of s^2_T, s^2v and s^2_c over all the districts and following the steps given for the district earlier.

ESTIMATES FOR THE URBAN AREAS

Let n_i the number of houses enumerated and y_i be the observed total of a category of livestock in the urban area. Let H_i be the number of houses in the area as per 1951 census. Then the estimated population for the i th urban area is

$$V_i = H_i \left(\frac{y_i}{n_i} \right) \ldots\ldots\ldots (2.6)$$

The estimate of sampling variance of V_i can be calculated on the same lines as for the rural area.

APPENDIX III

FIELD WORK

Bombay Survey. Four proformas were prescribed for recording the data in the survey enumeration. The first three (IA, IB, IC) were village forms and the last one, Form II was a household form. Form IA concerned with general information of a selected village regarding population, land utilisation statistics and total number of households and houses. This information was collected from the *Patwari* of the village. Form I B dealt with summary particulars of livestock enumeration as per the livestock census of 1951 for each selected village. This information was utilised to build up ratio estimates for livestock numbers. Form I C pertained to particulars and results of identification of the selected list of houses and households therein for each selected village. Form II was meant for recording livestock data for each of the households existing in the selected clusters of houses. Data were collected from head of the households followed by spot check of the animals to the extent possible. In case the enumerator was not able to contact the head of the household, information was collected from other inmates of the house or from neighbours stating in each case the name of the persons and the nature of relationship with the head of the household. For field work in the survey an *ad hoc* staff of 55 field enumerators was recruited. Besides, eleven were recruited from the Department of Agriculture, Bombay State. Each enumerator was entrusted with enumeration in 16 villages and one or two towns from either a single taluka or two nearby talukas.

Before the enumerator started his work in villages he visited tehsil offices at which National registers were available and selected the required number of clusters for each of the village under his jurisdiction.

Each enumerator was required to complete the work in each village within two days and move from village to village according to a certain order of movement prescribed for him at the commencement of the survey. For the sake of effective supervision an *ad hoc* staff of 5 inspectors was also recruited and the jurisdiction of each inspector corresponded to that of the Deputy Director in the State Department of Agriculture. Besides ensuring supervision over the work of enumerators, the inspectors were required to undertake independent enumeration in a sub-sample of villages and separately report the results.

The field work was also supervised by the statistical officers of the

Department of Agriculture in the State Government working under the
Agricultural Statistician who was in charge of the general administra-
tive control and supervision of the work. The actual work of enumera-
tion was also inspected in a few villages by the Statistical staff of the
I.C.A.R. All the technical and administrative details of the survey
were finalised by an officer of the Council in consultation with officials
of the State Government, sufficiently in advance of the commencement
of the survey. The inspectors and enumerators were all trained in the
method of enumeration in batches at five centres, namely, Baroda,
Satara, Ahmedabad, Nasik and Dharwar before the commencement
of the survey, The training was followed by practical demonstration in
a nearby village. The training at the Baroda and Nasik centres was
imparted by officers from the Council while at the other centres it
was given by the statistical staff of the State Department of Agricul-
ture.

Each field enumerator was required to fill in the forms in triplicate, one to the Statistical Adviser I.C.A.R. and one for the Statistician, Department of Agriculture, Poona, while the third was retained by himself to answer any querries from the Statistical Adviser or the State Statistician.

Instructions and schedules of the Bombay survey are appended.

It may be relevant to quote here the definitions of household and house adopted during 1951 census. A 'household' is group of people who live together and take their food from the common kitchen. A 'house' is any human dwelling with a separate main entrance.

The same definitions were adopted for these surveys too. Further, villages selected were revenue villages. Actually, the definition taken into account is "inhabited revenue mauzas other than which have been wholly absorbed in towns." Among urban areas were covered municipalities, notified areas, town areas, cantonments.

APPENDIX IV

SAMPLE CENSUS OF LIVESTOCK IN BOMBAY STATE, 1954

Instructions to the Field Investigators. The present sample survey is to be carried out in 880 specified villages and a few towns (urban areas) of Bombay State, which are distributed among 87 talukas selected from all the Districts of the State. In each selected village or town, a sample of 20 houses is further selected in 4 clusters of 5 neighbouring houses each for actual enumeration of the livestock, poultry, agricultural implements, etc. possessed by each. The enumeration will be complete whenever the total number of houses is itself 20 or less than 20. Each field investigator will be entrusted with the enumeration in 16 villages and one or two towns which will be always located either in a single taluka or two nearby talukas. Further, the order of movement from village to village for each field investigator will be settled at the time of the field training and the investigator will be thereafter required to follow the programme so formulated, completing the work in each village within two days. Whenever the investigator is required to stay in any of the villages for a longer time for reasons not anticipated before, the change in programme will be immediately communicated to the inspector concerned with reasons therefor. The enumeration as per procedure detailed below, in all the villages and the urban areas (towns) assigned for enumeration to each investigator, will have to be completed within a total period of 40 days from the day of commencing the field work.

There are in all four types of forms prescribed to be filled up by the field investigator in course of the work. They are called forms IA, IB, IC and II of which the first three relate to certain general information pertaining to each selected village (or town) while the last one is meant for recording the details of enumeration for each occupied household of the selected houses at the time of enquiry in the different villages and towns assigned for work. Thus for the first three forms, the number of copies to be filled in by each investigator will be as many as number of villages and towns assigned to him for the enumeration work while the number of copies of Form II will be the total number of occupied households in the houses selected for enumeration. Form IA contains information on the general particulars such as the village population and land utilisation statistics for the selected villages. This information is to be extracted by the investigator from the village records maintained and made available to him

by the talatis of the villages after arrival in the village. Form IB contains particulars of livestock enumeration as per the 1951 livestock census for each selected village and this information is to be extracted from the relevant statement of the village records made available to him by the talati. Form IC consists of particulars and results of identification for the sampled list of houses in the selected villages. Items 1 to 5 of this form are just the same as corresponding items of the other forms and are self explanatory. Under item 6 of this form, the information to be furnished under columns (1) to (5) will be available with the investigator prior to the house to house enumeration, while the information to be furnished under columns (6) to (9) will be available to him in course of house to house enumeration. Column (1) relates to a serial listing of the 20 houses selected in the sample vertically one below the other, while in the corresponding position of column (2), the census number of the selected houses will be shown as found in the sample list supplied to each investigator. With this basic information available to him the investigator will while at the taluk headquarters (before proceeding to villages), refer to the national register for each selected village and extract from there information about the numbers assigned at the census time to the then occupied households in each selected house and also the name of each householder i.e. head of the family with father's name. This information will be recorded under columns (3) and (4). Having entered the names of the individual householders that are included in the selected sample of 20 houses, a serial listing of such households will be made in column (5). The investigator will then start the identification of the households mainly by means of the name of the householder recorded in column (4). He will, after identification, ascertain as to the existence or otherwise of the household and accordingly enter 'yes' or 'no' under cloumn (6) of the form. If he comes to know that a household under the same number happens to exist, he will further ascertain whether the occupant is the same as the householder named under column (4) or different. Against the entry in column (2) of each selected house, the investigator will also ascertain as to the number of households that have newly come up since the last census (such households will not have any number assigned to them) and enter this number in the corresponding position of column (8) (It should be noted however that the enumeration of livestock etc. is to be carried out for such households as well). In course of identification and enumeration in the 5 houses that constitute each of the selected clusters, the investigator will also come across houses and households in between and not enumerted in the 1951 human census for certain reasons and the number of all such houses and households covered in between the five houses constituting each of

the selected clusters as well as those between the house corresponding to the last listed house of the cluster and the house corresponding to the next number in the census list will be noted. The numbers of these houses and households will be shown as per classification (a) to (f) explained at the the bottom of the form. The houses which the investigators thus find as not included in the census list, may be either old houses which existed at the census time or they may be new houses built after the census took place. In respect of those which are old, the reason for their not being included in the census list will usually be due to the fact that they were not occupied at the time of the census. Some of such houses may be now occupied and some may still continue to be unoccupied. The number of all such houses which are found to be now occupied, will be shown against (a) while the number of occupying households therein will be shown as against (b). All the old houses which continue to be unoccupied will be shown against (e). As regards the new houses that the investigator comes across, the number of these which are found to be occupied will be shown against (c) and the number of households therein will be shown against (d), whereas all new houses found to be vacant will be shown against (f). It will facilitate enumeration to put down tally marks against each description whenever the investigator comes across one or several such houses or households singly or collectively and count all the tally marks shown against each letter towards the end and put down the numbers. The procedure is illustrated below with the help of an example. Let us say the four clusters selected in a village consist of houses serially numbered 6 to 10, 96 to 100, 116 to 120 and 141 to 145 in the census list of houses. All houses and households of descriptions (a) to (f) found in between the house numbers 6 to 11, will find a place in the first quarter of the form which corresponds to entries of the five houses constituting the first selected cluster. Similarly, those coming in between 96 to 101 will find a place in the second quarter of the form and so on.

As stated earlier, one separate copy of Form II will be filled up for each of the occupied households that the investigator will come across in the selected houses. Here again, items 1 to 5 are similar to the corresponding items of the other forms. If the household is one of those serially listed in Form IC, the serial number and census number of the house and household will be shown as against (a) and (b) respectively of item 6. If the household enumerated is however a new one, there will not be either serial or census numbers to report against (b) and the description that it is a new household, will be entered there instead. In filling up this form the investigator should, as far as possible, contact the householder (the head of the family)

himself (or herself) and obtain the required information directly. In case of non-availability of such persons or any other difficulty however, the person interviewed should be one closely related to the head of the family and his relationship to the head of the family should be mentioned against (b) of item 7. The number of livestock, poultry, etc. of various descriptions mentioned under items (8) to (12) will all refer to the particular time of the investigator's visit to the househould and a spot verification of the numbers to the extent possible should follow in all cases where such inspection is feasible.

In all the four forms prescribed to be filled up, the investigator will notice that there is one last item always pertaining to the time taken for recording the entries. The investigator should bear this in mind and for that purpose he will make a note of the time when he first starts the enquiry necessary to fill up each particular form and also the time when he completes all the entries therein. As soon as the work of enumeration in a village is over, these filled up forms will be sent directly to the Statistical Adviser, Indian Council of Agricultural Research, Library Avenue, New Delhi 12, without any delay.

SAMPLE SURVEY OF LIVESTOCK, BOMBAY STATE, 1954

Form I A : General Agricultural Statistics of the selected villages

1. Name of the Enumerator.. 2. District..

3. Taluka.................................. 4. Circle.................................... 5. Village....................................

6. Total number of (a) occupied houses and (b) households therein according to the 1951 population census } (a) (b)

7. Additional number of (a) occupied houses and (b) households therein up to date since the 1951 census } (a) (b)

8. Total population (as per 1951 census)

9. Geographical area (in acres)

10. Net area sown (in acres) during 1952-53

11. Total survey numbers as at present

12. Details of area sown (in acres) during 1952-53

(a) Cereal crops

i) Paddy

(b) Oil-seed crops

i) Safflower

ii) Bajri

iii) Kharif Jowar

iv) Maize

v) Rabi Jowar

vi) Wheat

vii) Fodder

ii) Groundnut

iii) Til

(c) Pulses

(d) Cotton

13. Details of area not sown (in acres) during 1952-53

(a) Available for cultivation

i) Culturable waste

ii) Permanent pasture and other grazing lands

iii) Tree crops, groves and bushes

iv) Current fallows

v) Other fallows

(b) Not available for cultivation

i) Forest

ii) Barren and uncultivable land

iii) Land put to non-agricultural uses including home steads, grave-yards, lakes, canals, tanks and roads

14. a) Date

b) Time taken for entries

Signature of the Enumerator

Form I B : Particulars of Livestock, Poultry and Agricultural Machinery for the Selected Villages as per 1951 Livestock Census

1. Name of the enumerator.. 2. District...

3. Circle.. 4. Taluka.................................... 5. Village.................................

6. BOVINES

Above 3 years

Male	Cattle	Buffaloes
Breeding bulls		
Working bulls and bullocks		
Not in use for breeding or work		
Others		

Female	Cattle	Buffaloes
In milk		
Dry		
Not calved		
Used for work only		
Others		

Below 3 years

		Cattle	Buffaloes
Between 1 and 3 years	Male		
	Female		
Below 1 year	Male		
	Female		

9. Bovines :

Horses and ponies	Above 3 years	Male
	Under 3 years	Female
Goats	Above 1 year	Male
	Under 1 year	Female
Sheep	Above 1 year	Male
	Under 1 year	Female

10. Poultry :

Hens

Cocks

Chickens

Total

11. Other animals :

Donkeys

Mules

Camels

Total

12. Agricultural machinery

Ploughs (wooden)

Ploughs (iron)

Blade harrows

Seed drills

Carts

Sugarcane crushers

Oil pumps

Chaff Cutters

Others

13. a) Date
b) Time taken for recording the entries

Signature of the Enumerator

SAMPLE SURVEY OF LIVESTOCK, BOMBAY STATE, 1954

Form I C : Particulars and Results of Identification in the sample list of Houses in the Selected Villages

1. Name of the Enumerator..

2. District....................... 3. Taluka....................... 4. Circle....................... 5. Village.......................

6. PARTICULARS OF IDENTIFICATION

A. By reference to records				B. By inspection				
Sl. No. of the house	Census No. of the house	Census No. of the household	Name of the householder with the father's name	Sl. No. of the household in sample	Does the household continue to exist or not?	If 'yes' is householder the same or different?	No. of new householders that have come up	Houses and households not enumerated in the census but observed in between the five selected numbers
1	2	3	4	5	6	7	8	9
								(a)
								(b)
								(c)
								(d)
								(e)
								(f)
								(a)
								(b)
								(c)

								(d)
								(e)
								(f)
								(a)
								(b)
								(c)
								(d)
								(e)
								(f)
								(a)
								(b)
								(c)
								(d)
								(e)
								(f)

7. Date

(b) Tim: taken for entries

Signature of the Enumerator

Index to col. (9) of item 6 : (a) old houses not occupied before but now occupied, (b) corresponding households, (c) new occupied houses, (d) corresponding households, and (e) and (f) vacant houses old and new respectively.

SAMPLE SURVEY OF LIVESTOCK, BOMBAY STATE, 1954

Form II : Particulars of Livestock, Poultry and Agricultural Machinery for the Selected Households in Selected Houses

1. Name of the Enumerator........................ ....
2. District..
3. Taluka............................
4. Circle............................
5. Village....... ....
6. Serial No. & census No. of (a) the house and (b) the house hold as in I.B. } (a)........................ (b)........................
7. (a) Name of the householder & (b) source of information } (a)........................ (b)........................

8. BOVINES

Above 3 years						Below 3 years		
	Male			Female			Cattle	Buffaloes
	Cattle	Buffaloes		Cattle	Buffaloes			
Breeding bulls			In milk			Between 1 and 3 years: Male		
Working bulls and bullocks			Dry			Between 1 and 3 years: Female		
Not in use for breeding or work			Not calved			Below 1 year: Male		
Others			Used for work only			Below 1 year: Female		
			Others					

9. Bovines :

		Male
	Above 3 years	
Horses and ponies		Female
	Under 3 years	
		Male
	Above 1 year	
Goats		Female
	Under 1 year	
		Male
	Above 1 year	
Sheep		Female
	Under 1 year	

13. a) Date
    b) Time taken for recording the entries

10. Poultry :

Hens

Cocks

Chickens

Total

11. Other animals :

Donkeys

Mules

Camels

Total

12. Agricultural machinery

Ploughs (wooden)

Ploughs (iron)

Blade harrows

Seed drills

Carts

Sugarcane crushers

Oil pumps

Chaff Cutters

Others

Signature of the Enumerator

APPENDIX V

SCHEME FOR SUPERVISION AND SAMPLE ENUMERATION—ALL-INDIA LIVESTOCK CENSUS, 1956

Introduction. Reliable statistics of livestock numbers constitute an essential pre-requisite for a proper planning of livestock development in the country. The need for collection of the statistics was recognised by the Government of India as early as 1919 when it decided to organize the first All-India Livestock Census and to repeat it every five years thereafter. So far, 7 censuses have taken place in this series and the 8th census is to take place during April, 1956. The part-time services of the local village officials in rural areas and the staff of the municipalities and like institutions in non-rural areas are normally utilised for conducting the census. The complete enumeration of livestock as followed in the census is essential for providing the necessary basic details at the taluka and village level at periodical intervals. In order to ensure the reliability of the census data it is essential to have proper scientific supervision over the field work. The lack of such supervision in the past had brought into question the quality of the census data as has been remarked by the National Income Committee and others. Besides, results of the census are reported a considerable time after the completion of the census due to the unavoidable time lag in processing the voluminous data. It would be desirable to have more rapid estimates of number under major categories for broad administrative units, for administrative action. It is also desirable to have an independent check on the accuracy of the census.

Object. The I. C. A. R. has studied and established during the past five years the feasibility and usefulness of sampling methods in rationalising the methods of supervision with a view to improving the quality of the census data and has also evolved a technique of sample enumeration useful in furnishing independent and timely estimates of reasonable accuracy of livestock numbers under major categories for broad administrative units of the Indian Union. The objects of the present scheme are to implement in conjunction with the forthcoming census (i) rationalisation of supervision and (ii) sample enumeration immediately after the census for the purpose described above. The sample survey will also provide material useful in improving the plan for similar country-wide surveys that may be repeated, if necessary in the following inter-census years.

Duration and Coverage. Both the supervision on the rationalised basis and the sample enumeration will be conducted over the

entire Indian Union. The supervision period will coincide with the primary enumeration period of the census and will thus be generally spread over a period of one month immediately before the census date of reference, i.e., from the 15th March, 1956 to 14th April, 1956. The sample enumeration will commence immediately after the census date of reference and will be completed within five weeks thereafter, i.e., from 16th April, to 22nd May, 1956. The date of reference for the sample enumeration of livestock will be the actual day of visit of the field staff. The changes that might take place in the livestock position of each household included for sample enumeration since the 15th April, 1956 to the day of visit will also be recorded.

Other details of supervision and sample enumeration are described below.

Supervision. In order to improve the quality of field work in the census it is desirable to supervise the work of at least 5 per cent of the primary enumerators selected randomly. The supervision of one primary enumerator's work will usually take a day. Thus taking into account his other departmental duties it will not be possible for a departmental supervisor to supervise the work of more than, say five primary enumerators in the period of one month prescribed for supervision. In order that this intensity corresponds to a 5 per cent supervision it will be, therefore, necessary to fix the jurisdiction of a single supervisor as comprising of about hundred villages. It is hoped that the staff will be made available at this rate by the respective State Governments from the departments they choose to associate with the supervision. It is also proposed to supplement this departmental supervision by an independent supervision in ten villages and two urban areas in each district by one *ad hoc* investigator appointed exclusively for this purpose. The villages and urban areas to be assigned to departmental and *ad hoc* staff for supervision will be selected randomly in advance. A suitable programme fixing different dates of visit to the villages and urban areas selected in the sample will be drawn in advance for each one of the supervisors and the primary enumerators concerned with the sample will be informed in advance to be present at their respective centres on the day of supervision with a view to devoting the day for the primary enumeration work. The State Livestock Census Officers will be assisted by the District Officers designated with the control for the livestock census in ensuring that the supervision in areas selected under this scheme is carried out on the rationalised lines described above. Along with the Districts Officers, one *ad hoc* supervisor for four or five districts will also be appointed in each of the larger States exclusively for the purpose of assisting the State Livestock Census Officer in supervision.

Each one of the *ad hoc* and departmental staff associated with supervision will countersign the primary forms completed during their presence with the primary enumerator. Besides, a suitable form will be prescribed for each to record a report of his supervision in each village and the departmental staff will both prepare their report of supervision in duplicate and send one copy to the Statistical Adviser, I.C.A.R. and the other copy immediately after the supervision in each village, to the State Livestock Census Officer or officers nominated by him for this purpose. For each of the ten villages and two urban areas supervised by the *ad hoc* investigators in each district, the primary enumerators concerned will send the completed registers together with an abstract statement for the village, immediately after the completion of the primary enumeration, to the *ad hoc* supervisor concerned with the district. The *ad hoc* supervisor will check up the totals in the abstract statement of the village and forward the totals for all the villages and urban areas of the supervision sample falling under his jurisdiction and supervised by the *ad hoc* investigator to the Statistical Adviser, I.C.A.R. New Delhi.

In order to facilitate the commencement of supervision by *ad hoc* staff from the 15th March, 1956, the recruitment of the *ad hoc* investigators in each district will be completed by 7th March 1956 and arrangements will be made for his attendance at one or two of the primary reporters' training classes that may take place in the district between 7th March and 15th March before he commences the supervision. The *ad hoc* supervisor will be recruited from 1st March, 1956.

Sample Enumeration. The plan for the sample enumeration which will commence from 16th of April onwards, will be one of multi-stage stratified sampling with the districts as strata in sampling urban areas and tehsil (or taluka) as strata in sampling rural areas. The scale of sampling is determined with a view to provide the estimates of numbers under broad categories of livestock with about 3 per cent to 5 per cent sampling error separately for each of the 15 States reported as having 5 million or more bovine population according to the 1951 census and an overall sampling error of about 1 per cent for the entire Indian Union. For each of these 15 States the sample from a district will consist of 15 villages and three urban areas or 20 villages and four urban areas depending on the number of districts, average size of a district and the 1951 bovine population in the State. For each of remaining States the sample from a district will consist of 10 or fewer villages together with one or two urban areas depending on the size of the State. The total number of villages and urban areas that will be selected for each of the different States are shown in the statement appended. The urban areas in each district will be selected

with replacement and probability proportional to the respective number of households according to the 1951 human census. The selection of villages from within each tehsil or taluk will be according to a simple random sample procedure, the actual break up of the sample among different taluks or tehsils of a district being in proportion to the respective bovine population at the 1951 livestock census. A sample of 20 occupied houses falling under four randomly chosen clusters of five houses bearing consecutive census numbers will be selected for the actual enumeration from each of the selected villages. Similarly a sample of 50 occupied houses in ten (suitably distributed between the different wards, if any) randomly chosen clusters of five houses bearing consecutive census number will be selected from each of the urban areas included in the sample.

In each of the 15 larger States, the sample enumeration for ten villages and two urban areas in the sample selected from each district will be carried out by the *ad hoc* investigator provided for the district under the scheme. The sample enumeration in the remaining villages and urban areas selected in the district will be distributed between the State departmental staff who should preferably be of the rank of taluk officers from whatever department they are nominated for this purpose. For these 15 States, the scheme will also provide for the appointment of one *ad hoc* supervisor to supervise the work of sample enumeration by the *ad hoc* and departmental staff in every four or five contiguous districts. In the other States, the departmental staff will not participate in the sample enumeration which will be carried out entirely by the *ad hoc* investigators. The *ad hoc* investigators' work will be directly supervised by the State Livestock Census Officer or his representative and no *ad hoc* supervisors are provided for this purpose except for Pepsu, Saurashtra and Jammu and Kashmir which will have one superviser each because of their geographical size.

All the *ad hoc* investigators and the departmental staff concerned with the sample enumeration work in each State will be trained collectively or in batches at convenient centres about the sample enumeration plan by the *ad hoc* supervisors in all States where such supervisors are provided. In the other States, where the sample enumeration will be carried out by the *ad hoc* investigators only, this training to the investigators will be given by the State Livestock Census Officer himself or his respresentative at convenient centres in the State. This training also will be completed between 7th and 15th March, 1956, preferably immediately after the *ad hoc* investigators have attended the training classes for the primary reporters. The *ad hoc* supervisors themselves will be trained for this purpose by the State Livestock Census Officer or their representatives in advance in the first week of March, 1956.

The *ad hoc* supervisors or the State Livestock Census Officer will once again gather all the *ad hoc* and departmental staff concerned with the sample enumeration on 15th April, 1956 for imparting a refresher training before the latter begin the sample enumeration work. The sample plan for enumeration will be supplied to the respective investigators and the departmental staff concerned at the time of this refresher training. The programme for visiting the different villages and urban areas assigned will also be prepared for each one of the field staff. Immediately after the refresher training, the field staff will start the sample enumeration. Before conducting the sample enumeration of villages in a tehsil or taluka, the staff will go to the tehsil office and collect the up-to-date list of houses for the villages and urban areas which they have to enumerate in that particular tehsil. These lists will be required by them in the random selection of clusters of houses with the help of random numbers supplied against the name of each village or urban area. It will, therefore, be necessary to arrange for the receipt of copies of up-to-date house-lists from all the primary reporters by 15th March, 1956 at the respective tehsil or taluka offices.

There will be two types of forms prescribed in connection with the sample enumeration scheme. Of these one will be a village or urban area form which will contain general information concering items such as land utilisation, etc. The other form will be a form containing the minimum list of items included in the census form together with information for each sample household about breed distribution of cattle, milk production on the day previous to the visit and changes in the livestock position that had taken place over a period of three months prior to 15th April, 1956. All the forms will be filled in duplicate. The original set will be sent to the Statistical Adviser, I.C.A.R., immediately after the completion of the work in a village or an urban area while the other set will be sent simultaneously to the *ad hoc* supervisor in States where such supervisors are provided. The supervisors after scrutiny will deposit the duplicate set with the Livestock Census Officer or a State Officer nominated by him for this purpose.

Administrative Control and Technical Guidance. All the *ad hoc* personnel and the departmental staff associated with the supervision and sample enumeration will work under the administrative control of the State Livestock Census Officer. The Statistical Adviser, I.C.A.R., with cooperation from the States' Statisticians dealing with agricultural/animal husbandry statistics will be responsible for the technical guidance in the scheme of supervision and sample enumeration by both *ad hoc* and departmental staff.

Budget and Duration of Posts. The number of *ad hoc* investi-

gators and supervisors proposed for each of the States is indicated in the statement appended. The *ad hoc* investigators will be employed for the period from 7th March to 22nd May, 1956 while the *ad hoc* supervisors will be employed from 1st March, 1956 to 31st May, 1956. A consolidated pay of Rs. 100/- per month together with a travelling allowance of Rs. 50/- per month on an average is proposed for the *ad hoc* investigators. A consolidated pay of Rs. 200/- per month plus T.A. of Rs. 100/- per month is proposed on an average for the *ad hoc* supervisor. The scheme also provides for the appointment of one clerk in each of the 15 States where separate estimates are intended to be given and this clerk will assist the State Livestock Officer for a period of three months from 1st March, 1956 to 31st May, 1956. Compilation and statistical analysis of data from the sample enumeration scheme and *ad hoc* supervision will be done at the I.C.A.R. The staff at the I.C.A.R. will consist of one Assistant Statistician, two investigators, two assistants, and eight computors supplemented by the usual secretariat staff. The Assistant Statistician and two assistants will be in position for a period of 10 months (1st February to the 30th November) while the two investigators and eight computors will be brought on only on 1st May, 1956 and maintained for a period of six months only thereafter, i.e., up to the 31st October, 1956 by which time the estimates together with the sampling errors are expected to be ready.

Draft forms of the supervision reports and proformas for the sample enumeration together with instructions will be prepared and supplied to the States by the 1st October, 1955 to be sent for printing.

LIVESTOCK CENSUS, 1956—SUPERVISION AND SAMPLE ENUMERATION

Statement showing the scale of sampling and strength of *ad hoc* Staff in each State

S.No.	State	SAMPLE SIZE *Ad hoc* staff U		Deptt. staff U		No. OF *Ad hoc* staff I	
		U	R	U	R	I	S
1.	Andhra	22	110	22	110	11	3
2.	Assam	26	130	13	65	13	3
3.	Bihar	32	160	32	160	16	4
4.	Bombay	58	290	58	290	29	6
5.	Madhya Pradesh	44	220	44	220	22	5
6.	Madras	30	150	30	150	15	3
7.	Orissa	26	130	26	130	13	3
8.	East Punjab	26	130	13	65	13	3
9.	Uttar Pradesh	102	510	51	255	51	8
10.	West Bengal	30	150	15	75	15	3
11.	Hyderabad	34	170	17	85	17	4
12.	Madhya Bharat	32	160	16	80	16	2
13.	Mysore	20	700	20	100	10	2
14.	Rajasthan	50	250	25	125	25	5
15.	Vindhya Pradesh	16	80	8	40	8	2
16.	Pepsu	16	80	—	—	8	1
17.	Saurashtra	10	50	—	—	5	1
18.	Travancore-Cochin	8	40	—	—	4	—
19.	Jammu & Kashmir	12	48	—	—	6	1
20.	Ajmer	2	10	—	—	1	—
21.	Bhopal	4	20	—	—	2	—
22.	Bilaspur	2	10	—	—	1	—
23.	Coorg	2	10	—	—	1	—
24.	Delhi	2	10	—	—	1	—
25.	Himachal Pradesh	8	40	—	—	4	—
26.	Kutch	2	10	—	—	1	—
27.	Manipur	2	10	—	—	1	—
28.	Tripura	2	10	—	—	1	—
	Total	620	3088	390	1950	310	59

U : No. of urban areas R : No. of rural areas
I : Investigators S : Supervisors

Scheme for Rationalised supervision and sample enumeration in the Livestock Census..............................State, 1956.

FORM I

Particulars of the village/urban area selected for sample enumeration.

District......................Taluk/Tehsil/Sub-division..............................

Village/Urban area..

Name of Enumerator..............................Total No. of occupied houses

Designation and HQ..............................Total No. of occupied houses (According to the revised list)

Geographical area (in acres).........Gross cultivated are in acres (1954-55)

No. of tractors working in the village at the time of enumeration

Private.................................

Government...........................

Details of area not sown (in acres) during 1954-55

Not available for cultivation		Available for cultivation	
(a) Forest		(a) Culturable waste	
(b) Barren and uncultivated land		(b) Permanent pastures and other grazing-lands	
(c) Land put to non-agricultural uses including home steads, grave-yards, lakes canals, tanks and roads		(c) Miscellanous tree crops and groves	
		(d) Current fallows	
		(e) Old fallows	
Total		Total	

Details of cultivated area sown (in acres) during 1954-55

Fodder crops		Cereals and other crops	
Name	Area (in acres)	Name	Area (in acres)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
Total		Total	

Signature.......................................

Date..

LIVESTOCK CENSUS.......................... - ....STATE, 1956

LIST OF OCCUPIED HOUSES AND HOUSEHOLDS

District........................Taluk/Tehsil/Sub-division.........................
Village/Urban area...
Name of the primary Enumerator........... - ....Designation and HQ..................................

Date of completing compilation...........................Actual time taken in compilation (in hours).........................

Serial number of the house	Census number of the house	Census number of the house-hold	Name of the head of the household	Serial number of the house	Census number of the house	Census number of the house-hold	Name of the head of the household

District.......... ....Taluk/Tehsil/Sub-divison...............................

(a) Random Nos. given

(b) Cluster Nos. selected

(c) Serial Nos. of the houses included in the selected cluster

Serial Nos. of the houses selected as in the house list	Census No. of the house	Census No. of the household	Name of the head of the household
Total of clusters			
Village total as in 1951 census			

SCHEME FOR RATIONALISED SUPERVISION AND SAMPLE ENUMERATION IN THE LIVESTOCK CENSUS.................................. STATE, 1956

FORM II

Particulars of Livestock, etc. in selected households

Village/Urban area..........................Name of the Enumerator...........................Designation and Headquarter..........................

CATTLE

Male over 3 years						Female over 3 years					
No. of breeding bulls		No. of working bullocks		Useless bulls and bullocks i.e. not in use for breeding or work	Total	Breeding cows i.e., cows kept for breeding or milk production			Dry	Not calved even once	Total
Breed	No.	Breed	No.			Breed	No.	Individual milk yields on the previous day (in seers)			
5	6	7	8	9	10	11	12	13	14	15	16

CATTLE

Females over 3 years					Young stock						
Cows used for work			Useless cows i.e. not in use for work or breeding purpose	Total	Under one year		1 to 3 years		Total		
Breeding	Others	Total			Males	Females	Males	Females	Males	Females	Total
17	18	19	20	21	22	23	24	25	26	27	28

CATTLE			BUFFALOES									
Total cattle			Males over 3 years				Females over 3 years					
							Breeding cows, i.e., cows kept for breeding or milk production					
Males	Females	Total	Breeding bulls	Working bullocks	Useless bulls and bullocks not in use for breeding	Total	In milk	Individual milk yield on the previous day (in seers)	Dry	Not calved even once	Total
29	30	31	32	33	34	35	36	37	38	39	40

BUFFALOES

Females over 3 years					Young stock						
Cows used for milk			Useless cows i.e., not in use for work or breeding	Total	Under one year		1 to 3 years		Total		
Breeding	Others	Total			Males	Females	Males	Females	Males	Females	Total
41	42	43	44	45	46	47	48	49	50	51	52

BUFFALOES								SHEEP			
Total buffaloes			Total bovines			Others					
Males	Females	Total	Males	Females	Total	Adult	Young stock	Up to one year	Over one year		
									Males	Females	Total
53	54	55	56	57	58	59	60	61	62	63	64

GOATS				Horses and Ponies				Others	
Up to one year	Over one year			Up to three years	Over 3 years			Mules	Donkeys
	Males	Females	Total		Horses	Ponies	Total		
65	66	67	68	69	70	71	72	73	74

Others		Poultry				Ducks			
Camels	Pigs	Hens	Cocks	Chickens	Total	Ducks	Drakes	Ducklings	Total
75	76	77	78	79	80	81	82	83	84

Agricultural Implements

Ploughs		Sugarcane crushers					
Wooden	Iron	Carts	Worked by power	Worked by animal	Oil engines with pumps for irrigation	Electric pumps for irrigation	*Ghanis*
85	86	87	88	89	90	91	92

Changes in livestock, poultry and all other details since 15 April, 1956 to the date of enumeration					Change in cattle and buffaloes number during preceding three months prior to date of enumeration				
Due to birth	Due to death	Due to sale	Due to purchase	Due to other reasons (to be specified)	Due to birth	Due to death	Due to sale	Due to purchase	Due to other reasons (to be specified)
93	94	95	96	97	98	99	100	101	102

Signature..

Date...

LIVESTOCK CENSUS,....................................STATE, 1956

SUPERVISION REPORT

District......................Taluk/Tehsil/Sub-division.............................

Village/Urban area..

Name of the Supervisor.................Designation and HQ.............

1. Total number of occupied houses in the village..................

2. Was the primary enumerator entirely available for this work on t day of your visit............................

   If not, state the reasons given by him and your own observation..
   ....

3. How many houses were enumerated before your visit and what was the time taken by the primary enumerator .... (Specify the number of days worked and the average number of hours spent per day)

4. (a) Did you find it necessary to check part of the enumeration completed and if so, state reasons......................

   (b) No. of houses re-enumerated for checking and the time spent for the purpose...

   (c) Number of additional houses enumerated by the primary enumerator in your presence and time spent for the purpose...
   ....

5. Number of houses, if any, as discovered by you not included in the list and the reasons furnished by the primay enumerator.............
   ....

6. Did the primary enumerator complain of any difficulties in correctly entering the information and if so of what nature ?

7. While working with him or in course of physically checking the enumeration completed by the primary enumerator, have you had any occasion to correct him ? If yes, give details.

Time and date of arrival at the village..

Time and date of departure from the village.................................

Signature...

Date...

APPENDIX VI

SAMPLE SURVEY FOR IMPROVEMENT OF LIVESTOCK STATISTICS, BOMBAY STATE 1954

List of items on which information was collected but not analysed for p. sentation in the report.

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1. Detailed information on horses and ponies, goats and sheep under different categories *viz.*
   (i) above three years, for male and female
   (ii) under 3 years, for male and female
2. Information on other animals *viz.*, donkeys, mules and camels.
3. Information on female cattle, under the categories of dry, not calved and used for work only.

APPENDIX VII

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